The young osteoarthritic hip:
Clinical outcome of total hip arthroplasty
and a cost-effectiveness analysis

Vincentius J.J.F. Busch
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Colofon

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The young osteoarthritic hip: clinical outcome of total hip arthroplasty and a cost-effectiveness analysis

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Introduction
**Introduction**

Total hip arthroplasty (THA) has proven to be a highly successful procedure in terms of improving quality of life and cost-effectiveness in older patients\(^1\,^2\). With this success, an extension of indications for total hip arthroplasty was noted and the number of primary hip arthroplasties in Europe has risen to more than 600,000 annually\(^3\). Many different types of hip prostheses are currently available. Historically, hip prostheses are categorised according to their fixation: with or without bone cement.

![Example of a cemented total hip arthroplasty with polyethylene cup and polished stem.](image)

![Radiographic appearance.](image)

The development of the modern cemented hip prosthesis (Fig. 1) started in the 1960s with the low friction arthroplasty designed by Sir John Charnley\(^4\). The design was eventually based on the use of a metal stem with a fixed 22 mm head, which articulates with a polyethylene cup.

This concept was a breakthrough in the development of the modern total hip prosthesis. Sir John Charnley introduced the use of polymethylmethacrylate bone cement to fill the gaps between the implant and bone, hence creating a stable situation for the metal stem and the polyethylene cup. He had such acceptable results that even today, the long-term data of the survival of the original Charnley prostheses with the polyethylene cup are part of the gold standard of THA. However, the
long-term outcomes in younger patients were initially less favourable. Subsequently, technical improvements like a better cementing technique and improvements in implant materials were introduced to try to overcome loosening and improve long-term survival. Unfortunately, implant loosening was still seen, especially in younger patients. Loss of implant fixation is mainly caused by aseptic loosening, a multifactorial process. During hip movement, friction of the metal head against the polyethylene cup results in small particles that accumulate in the joint cavity. These particles trigger the immune system by means of phagocytosis and activate cell types such as macrophages, fibroblasts, osteoblasts and osteoclasts. The inability to degrade these particles leads to a rise in the release of numerous cytokines and mediators that stimulate osteoclast formation and activity, leading to periprosthetic osteolysis.

This immune response that results in bone resorption around the components causes loosening, which has been described as “particle disease” and related osteolysis by Harris.

Since initially these wear-related problems were considered to be related to the use of cement, the concept of uncemented total hip designs (Fig. 2) gained popularity. These designs were developed specially for younger patients suffering from hip osteoarthritis. Initial fixation is achieved by press-fit placement of components.
Depending on the design of the implant, additional screws, pegs or fins at the rim of the acetabular component can help to maintain implant position before bone ingrowth and long-term fixation are achieved. In contrast to cemented implants, many of these uncemented implants are made of titanium with a roughened surface or a coating of hydroxyapatite to enhance bony ingrowth and improve fixation. Unfortunately, osteolysis was also observed around these cementless components. It was then realized that this phenomenon was not related to the bone cement itself, but to the generation of wear particles, mainly made from polyethylene (PE).

To decrease wear-related problems caused by these polyethylene particles, stronger types of polyethylene were developed. Highly cross-linked polyethylene and Vitamin E addition were introduced, but if these new materials will solve the problem remains uncertain, as a long follow-up is needed to determine survival.

A different strategy for solving the wear problem was the development of new bearings, like ceramic on ceramic and metal on metal. In addition, surgeons and producers realized that these new hard bearings could be very attractive for young patients. Not only because of lower wear rates but also because they would enable the use of larger diameter articulations to decrease the rate of dislocation. Based on these technical innovations, the resurfacing hip (Fig. 3) was introduced in young patients, based on a large metal head and a cup with a large inner diameter. The resurfacing hip prosthesis was a concept that had previously been used but had been abandoned at the end of the 1970s due to high failure rates. However, with the growing demands of young patients and facilitated by the potential advantage of low wear and new materials, the resurfacing hip prosthesis was introduced again. Part of the new introduction strategy was that the new resurfacing hip designs
were considered to better preserve bone on the femoral side than traditional hip designs and it was suggested that these implants are relatively easy to revise in case of loosening. The possibility of using large-diameter heads was expected to result in a better range of motion and a lower risk of dislocation. These potential advantages were used in the promotion of these implants in the orthopaedic practice and initially, younger patients were stimulated to take part in high level sports. This advice was adapted when it became known that survival of hip resurfacing had been compromised by high level of sports. Further research showed that the range of motion of a resurfaced and a conventional total hip were not significantly different, but larger-diameter heads were indeed associated with a lower risk of dislocation.

Recent literature shows high failure rates of resurfacing prostheses and national registries have confirmed these higher revision rates. This led to 2010 to withdrawal of one type of resurfacing hip prosthesis. However, the high mid-term failure rates were not limited exclusively to this implant and a high number of serious side effects were seen in several designs. The local metal ion debris, which is generated by these implants can cause severe local problems with a high incidence of so-called pseudotumors. In addition to local effects, these metal ions have shown to disseminate to other parts of the body by spreading to the lymph nodes, spleen, liver, and kidneys before being excreted in urine. General side effects have been described in relation to high levels of chromium and/or cobalt; for example, cardiomyopathy, risk of chromosomal aberrations and risk of carcinogenesis as well as neurological and endocrinological symptoms. The Medicines and Healthcare Products Regulatory Agency (MHRA), responsible for regulating all medicines and medical devices in the United Kingdom, released a Medical Device Alert stating that patients with metal on metal hip implants should be reviewed and monitored on a regular basis. The Dutch Orthopaedic Association has endorsed this warning by the MHRA and has formulated a guideline on this subject. The latest alert states that large diameter head (36 mm or more) metal on metal prostheses should not be implanted until further long-term results guarantee their safety.

Survival of THA in young patients has shown to be worse compared to survival in older patients. An explanation might be that young patients put higher demands on their prosthesis. Younger age by itself should be interpreted cautiously because activity levels may differ between patients. Pre-existing bone loss may also affect the outcome, as many younger patients already had bone stock.
problems at surgery. In normal hips, primary osteoarthritis is mostly seen in patients over 60 years.

Both cemented and uncemented stems have performed well in young patients showing survival rates of more than 90% at 10 years. A study on THA in patients younger than 55 years of age in Finland suggested that uncemented stems show a higher survival rate than cemented stems although this conclusion has been questioned. In general, we can conclude that survival of the femoral component is acceptable and that failure of the stem is not the main reason for revision of THA in young patients.

Most problems with fixation are seen at the acetabular side and high failure rates have been reported in several series of young patients. Clearly, the shift towards the use of uncemented cups in young patients has not solved the problem. Since cemented cups still show higher survival rates in younger patients compared to uncemented cups, there is limited evidence for the current trend of using uncemented cups in young patients. Polyethylene wear and osteolysis compromise the success rate of uncemented cups. Eskelinen et al. concluded from a nationwide study on THA in patients younger than 55 years that survival rates of uncemented cups are unsatisfactorily low when liner exchanges are taken into account. Evaluating modern hip designs, only the Harris Galante II cup showed a 10-year survival rate of more than 80%, with revision of the cup for any reason as endpoint. A recent report from the Swedish Hip Register showed that after stratification into age groups, the long-term component survival with revision for any reason was lower after uncemented THA in all but the oldest age group. A separate analysis of the cup revealed that uncemented cups had a significantly higher risk of cup revision due to aseptic loosening than cemented cups. This difference persisted even after exclusion of those revisions in which only liner exchange had been performed. Remarkably, the 2010 report of the Swedish Hip Registry stated that a reduced risk of cup revision was found for uncemented cups in patients up to 69 years. This clearly demonstrates that the most durable option for acetabular fixation in young patients is still a topic of debate.

The term “young patient” needs to be clarified as this term is used by numerous authors in different ways. The term “young patient” can mean active patients under 65 years or it was used for patients with a mean age of 25 years. In the first age group, most patients will suffer from primary osteoarthritis since in the latter,
practically all patients will suffer from an underlying disease. This also applies to the series of patients presented in this thesis and therefore, we would like to emphasize that these are different groups of patients and that results should be compared cautiously.

Several other factors influence the outcome of THA in young patients. In addition to primary osteoarthritis, young patients often suffer from an underlying disease like rheumatoid arthritis, Perthes disease, osteonecrosis or developmental dysplasia of the hip (DDH) that cause degenerative hip disease or secondary osteoarthritis. Because of these underlying diseases, hip anatomy may be altered and the accompanying bone stock deficiencies could make it difficult to achieve stability with a standard implant. Patients with DDH often show a deficient acetabular superolateral rim, whereas protrusio acetabuli is more often seen in rheumatoid patients. These variations in anatomy require a patient-matched solution which might compromise the survival of the reconstruction.

Depending on the type of acetabular defect, several techniques and implants can be used for reconstruction. A useful classification for acetabular defects has been made by the American Academy of Orthopaedic Surgeons (AAOS), committee on the hip (Table 2).

<table>
<thead>
<tr>
<th>Table 2:</th>
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<tbody>
<tr>
<td>Classification of acetabular deficiencies (AAOS)</td>
</tr>
<tr>
<td>Type I Segmental deficiencies</td>
</tr>
<tr>
<td>- Peripheral</td>
</tr>
<tr>
<td>- Central (medial wall absent)</td>
</tr>
<tr>
<td>Type II Cavitary deficiencies</td>
</tr>
<tr>
<td>- Peripheral</td>
</tr>
<tr>
<td>- Central (medial wall intact)</td>
</tr>
<tr>
<td>Type III Combined segmental/cavitary defects</td>
</tr>
<tr>
<td>Type IV Pelvic discontinuity</td>
</tr>
<tr>
<td>Type V Arthrodesis</td>
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</table>

A segmental defect (Type I) is a loss of cortical bone in the supporting hemisphere or a segmental defect of the medial wall. However, there should be no volumetric bone stock loss. In most cases with this type of defect, a superior rim defect is seen as in patients with DDH (Fig. 4 A).
Several authors advocate the restoration of the centre of hip rotation\textsuperscript{42-45}. If reconstruction with a standard cup is considered in a dysplastic hip, reconstruction of the superolateral rim is mandatory. A frequently reported option is the use of solid grafts with a cemented cup as described by Wolfgang\textsuperscript{46} and modified by Lida et al\textsuperscript{47}. Using this technique, the centre of rotation is restored and a standard acetabular implant can be used (Figure 4B). Comparison of grafting (32 cases) versus nongrafting (48 cases) of severe acetabular defects in a series of 64 patients showed higher survival rates for the grafted cases\textsuperscript{48}.

Impaction bone grafting with reconstruction of the rim using a mesh is a technique which was introduced and described by Slooff in 1984\textsuperscript{49}. Survival of 84\% at 15 years was reported in a series of 28 acetabular reconstructions in patients with DDH\textsuperscript{50}. Other surgeons prefer to use a reinforcement ring to achieve stability and good results have been reported\textsuperscript{51-54}. Based on the reported radiographic signs of loosening, long-term survival might be a problem in the future\textsuperscript{53,54}.

Medial wall defects are rarely seen in isolation but protrusion acetabuli can result in this isolated defect. It can be dealt with in several ways and probably the easiest way is to use an uncemented cup, especially those designs that are based on the principle of side-ingrowth. A disadvantage is that the deficient bone stock is not restored, which can make future revisions complicated. Bone grafting is a more
biological approach; both structural grafting and impaction grafting techniques have proven to be successful, including in patients with acetabular protrusion because of rheumatoid arthritis. Restoration of the original hip centre of rotation is also advocated in patients with acetabular protrusion.

A cavitated defect (Type II) consists of a volumetric bone loss of the acetabular cavity while the rim and medial wall remain intact. This is a frequently encountered condition, both in primary and revision hip surgery.

Filling the acetabular cavitated defect with bone cement should be reserved for elderly patients, as high failure rates have been reported for using only cement and the use of additional bone grafts has been recommended.

Techniques using bone grafts to reinforce the medial wall have been described with good results after a mean follow-up of 4 (range 3-9) years for cemented as well as uncemented cups. Unfortunately, reports of this technique with longer follow-up are lacking. Impaction bone grafting as described above offers another durable solution.

Most acetabular defects are combined segmental/cavitary defects (type III). Treatment is based on one of the techniques described above or a combination of them.

In case of pelvic discontinuity (type IV), a rare condition, there is total separation of the superior and inferior part of the acetabulum. As described in a review on the treatment of pelvic discontinuity, the main issues are healing the discontinuity and restoration of bone stock. Depending on the potential for healing, treatment should consist of plating the posterior column in combination with structural grafts or trabecular metal/cages. Custom-made implants can also be used, with or without additional allografts. Clear guidelines on the best type of implant or allograft are lacking because large series of patients treated for this condition are not available.

Treatment of patients with hip osteoarthritis and the related costs are a financial burden for society and if possible, length of hospital stay and costs should be minimised. In addition to the fact that long-term survival is of great importance for the individual patient, the financial impact for society could be limited if only implants with a known long-term survival are used. A recent study on data of the National Joint Registry shows that a possible cost saving to the NHS of more than
£18 million per year can be made if cemented instead of uncemented hip designs were to be used in England and Wales. As revision surgery of the hip is expensive compared to primary THA, we should choose our primary implants based on the available evidence. Currently, choices of implants are mainly based on the preferences of the surgeon or the tradition of an institute. Better insight in associated costs of implants and revision surgery will result in better use of financial resources.

Questions addressed in this thesis are:

1. How many hip arthroplasties are performed in young patients in the Netherlands and what types of hip prosthesis are most commonly used?
2. What is the outcome of cemented THA in very young patients under 30 years?
3. What are the radiographic and clinical results of acetabular impaction bone grafting in patients younger than 50 years at long-term follow-up?
4. What is the outcome of acetabular solid grafting in DDH-patients?
5. What are the radiographic and clinical results of uncemented THA in patients younger than 50 years?
6. Are the hip implant-choices for young patients in The Netherlands evidence-based?
7. What is the most long term cost-effective treatment of a young patient in need for a THA?

Outline of this thesis

This thesis focuses on the clinical outcome of THA in young patients and how to deal with acetabular defects. Question 1 is addressed in Chapter 2 which describes the distribution of hip implants in young patients in the Netherlands.

Chapter 3 describes the clinical outcome of cemented THA in patients younger than 30 years at the time of surgery (question 2). Question 3 is addressed in Chapter 4, which discusses the results of a series of young patients with an acetabular defect reconstructed with impaction bone grafting. Chapter 5 shows the outcome of the same group of patients with a longer follow-up.

Chapter 6 shows the outcome of solid grafting of the affected acetabulum in DDH-patients (question 4). The long-term outcome of the uncemented Zweymüller
A hip prosthesis in patients younger than 50 years is discussed in Chapter 7 (question 5).

Whether current choices for hip implants for young patients in the Netherlands are evidence-based (question 6) is discussed in Chapter 8.

Finally, the most cost-effective solution for a young patient in need for a THA was determined using a Markov-model; the results are presented in Chapter 9 (question 7).

Chapter 10 consists of the general discussion and summary of the studies presented in this thesis and the conclusion. Chapter 11 is the Dutch summary of this thesis.
References


Chapter 2

Hip implants in young patients in The Netherlands

Dutch Arthroplasty Register data
Chapter 2

Hip implants in young patients in the Netherlands

The Dutch Arthroplasty Register (in Dutch: Landelijke Registratie Orthopedische Implantaten, LROI) started in 2007 and contains the registration of all primary and revision hip and knee replacements performed in the Netherlands. The start of this national database was supported by Dutch healthcare insurance companies and gives transparency on the performance of implanted prostheses. All registered implants can be traced, which can be useful in case of any implant-related problems or recalls. Furthermore, it enables nationwide population-based monitoring of Dutch patients and therefore examining the preferences of Dutch orthopaedic surgeons.

The number of THAs performed in 1980 was 6,750. This number has risen to 16,000 in 1994 and to more than 23,000 in 2012. In the years 2009 - 2012, the number of THAs in the Netherlands has risen the past years as shown in Table 1. Data are presented starting in 2009, since in 2007 and 2008 not all THAs performed in the Netherlands were reported to the LROI.

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<tr>
<td></td>
<td>2009</td>
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<tr>
<td>Number of THA</td>
<td>21,001</td>
</tr>
<tr>
<td>Male (%)</td>
<td>33</td>
</tr>
<tr>
<td>Female</td>
<td>67</td>
</tr>
<tr>
<td>&lt; 50 yrs (%)</td>
<td>5</td>
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At the moment, numerous hip designs are available, as described in the previous chapter. Historically, the main classification was based on type of fixation: with or without cement. The term ‘hybrid construction’ refers to the combination of cemented and uncemented components. The restrictive term ‘hybrid’ is reserved for an uncemented cup with a cemented stem while a cemented cup with an uncemented stem is called a ‘reversed hybrid’. As currently resurfacing hip designs are used only in a selected group of patients, data are not presented in this chapter. The distribution of the different types of hip designs for patients of all ages used in the Netherlands in 2012 is shown in Figure 1. Uncemented implants account for more than 62% of all registered primary THAs in patients of all ages. Type of fixation was not reported of 83 THAs.
Figure 2 shows the method of fixation distributed per age group. In patients older than 85 at the time of their surgery, 38% were uncemented THAs. In patients younger than 50 years, uncemented implants were used in more than 78% of cases.

A standard definition of a “young patient” is lacking in literature and the term has been used for different age groups of patients, as explained in Chapter 1. This is illustrated by observing the indications for THA in the different age groups. Figures 3a-c show the primary diagnosis of patients receiving a THA in 2012. In patients of all ages (Fig. 3a), more than 87% received a THA because of primary osteoarthritis. A diagnosis as dysplasia for example counted only for 1.9%.

In patients younger than 50 years at the time of surgery, primary osteoarthritis counted for 62.2% of cases (Fig. 3b). Dysplasia counted for 12.9% of cases.

In patients younger than 30 years at the time of their THA, only 26.9% had primary osteoarthritis as the diagnosis; almost 18% had dysplasia of the hip (Fig 3c). Secondary osteoarthritis accounted for 73.1% of 78 registered THAs.
Fig. 3A
Diagnosis of total registered number (n=24,595) of patients (all ages) for primary THA in the Netherlands in 2012. Source data LROI - graphics LROI-Dashboard in ProMISe accessed December 2013

Fig. 3B
Diagnosis of patients younger than 50 years at the time of their primary THA in 2012. Source data LROI - graphics LROI-Dashboard in ProMISe accessed December 2013

Fig. 3C
Diagnosis of patients younger than 30 years at the time of their primary THA in 2012. Source data LROI; graphics LROI-Dashboard in ProMISe accessed December 2013
LROI data are registered in an internet-based datamanagement system called ProMISE (Project Manager Internet Server) from the section Advanced Datamanagement at the Leiden University Medical Centre (LUMC). ProMISE is an internet based application for the design, maintenance and use of clinical data management projects. Aggregated or anonymous data are available for study objectives according to the regulations of the LROI, after approval of the scientific committee of the LROI. Here, access to summary data on primary hip implants was obtained according to the above mentioned regulations. Several case mix variables of patients were available, such as gender, age, diagnosis and ASA score. BMI, smoking and Charnley Score were added to these variables in June 2013. The implant variables available are fixation method (uncemented, hybrid or cemented) and type of prosthesis (total, resurfacing or hemi-prosthesis).

Countries like Sweden and Australia have registered implants for many years, which has shown to be of great benefit in tracking implant behaviour and detecting early failures. Since the start of the Dutch Arthroplasty Register in 2007, coverage of registration has improved to 94% of all hip and knee replacements in 2012.

Besides the earlier mentioned case mix variables, Patient Reported Outcome Measures (PROM’s) were added to the registration in 2013. This will give us better insight into the performance of different types of prostheses and hospitals, as well as how patients experience their hip or knee replacement. Registration of other joint replacements of shoulder, elbow, wrist and ankle will start in 2014.
Cemented total hip arthroplasty in very young patients

Cemented hip designs are a reasonable option in young patients

Busch VJ
Klarenbeek R
Slooff T
Schreurs BW
Gardeniers J

Clinical Orthopedics and Related Research. 2010 Dec; 468(12): 3214-20
Abstract

*Background:* Young patients with degenerative cartilage disease of the hip remain a challenge for the orthopaedic surgeon. Different treatment options are available of which uncemented hips are the most popular owing to long-term concerns about cemented implants. As an alternative, we have used a cemented hip design in combination with bone impaction grafting in patients with acetabular defects.

*Questions/purposes:* We therefore determined the survival rates and radiological failures of cemented THA in patients younger than 30 years and reported clinical scores, complications and current state of the revised THAs.

*Methods:* We retrospectively reviewed all 48 patients (69 hips) younger than 30 years at the time of surgery who had a primary cemented THA performed between 1988 and 2004. Acetabular defects were reconstructed using bone impaction grafting in 29 hips. Mean age at surgery was 24.6 years (range, 16–29 years). Revisions were documented, radiographs were analyzed, and the Kaplan-Meier method was used to determine survival for different end points. No patient was lost to followup, three patients (four hips) had died. Minimum followup was 2 years (mean, 8.4 years; range, 2–18 years).

*Results:* Eight hips were revised (three for infection and five for aseptic loosening) and one hip dislocated for which open reduction was necessary. One additional cup was considered a radiographic failure. The 10-year survival was 83% (95% confidence interval, 69%–92%) with revision for any reason as the end point and 90% (95% confidence interval, 77%–96%) with revision for aseptic loosening.

*Conclusions:* We found a high survival rate of these cemented THAs in young patients. In young patients with acetabular bone defects we recommend reconstruction using cemented implants with bone impaction grafting.
Introduction

THA restores hip function, relieves pain, is cost-effective, and associated with high survival rates. Given this experience indications for THA have now been extended to younger ages including patients younger than 30 years. However, most patients under the age of 30 years with osteoarthritis have some underlying disorder, such as developmental dysplasia of the hip, Legg-Calve-Perthes disease, or juvenile rheumatoid arthritis. Bone stock deficiencies and bone deformations often are present and can be an additional problem in achieving a stable and durable reconstruction.

Several options are available to deal with acetabular defects in young patients. The most commonly used is likely an uncemented cup and if necessary a reinforcement ring, placed with or without bone grafts. Reported survival rates (with revision as an endpoint) on uncemented hips in patients younger than 30 years with a minimal followup of 10 years vary from 49% to 90%. We have preferred a cemented THA in our young patients and to reconstruct any acetabular defects with bone impaction grafting in combination with a cemented cup.

The purpose of our study was to (1) determine survival of cemented prostheses in patients younger than 30 years and whether differences exist between hips placed with and without acetabular bone impaction grafting; (2) determine the clinical outcome of the surviving hips; (3) define radiographic failures; and (4) determine complications and current state of revisions.

Patients and Methods

We retrospectively reviewed all 48 patients (69 hips) younger than 30 years of age who had primary cemented THAs for primary or secondary osteoarthrosis between April 1988 and May 2004. Indications for THA were mainly osteonecrosis of the femoral head and juvenile rheumatoid arthritis (Table 1). Nineteen hips had previous surgeries at the hip. We excluded patients who had reconstruction for tumors. There were 32 female (46 hips) and 16 male patients (23 hips) with a mean age at operation of 24.6 years (range, 16.0–29.0 years). Twenty-one bilateral THAs were performed, and in two of these patients, the procedure was completed in a
single surgery. Three patients (four hips) died 1.4, 8.6 and 9.1 years after operation but they were evaluated at the outpatient clinic on a regular basis until their deaths and the data were included in the analyses. One patient with Crohn’s disease died of sepsis after colorectal surgery and another patient died because of aplastic anemia. The cause of death of a patient with juvenile rheumatoid arthritis was not known. The minimum followup was 2 years (mean, 8.4 years; range 2–18 years). No patient was lost to followup.

### Table 1: Indications for THA

<table>
<thead>
<tr>
<th>Indication</th>
<th>Number of hips</th>
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<tbody>
<tr>
<td>Juvenile rheumatoid arthritis</td>
<td>18</td>
</tr>
<tr>
<td>Osteonecrosis of femoral head</td>
<td>21</td>
</tr>
<tr>
<td>Systemic lupus erythematosus</td>
<td>7</td>
</tr>
<tr>
<td>Acute lymphatic leukemia</td>
<td>3</td>
</tr>
<tr>
<td>Crohn’s disease</td>
<td>3</td>
</tr>
<tr>
<td>Nephropathy, kidney transplantation</td>
<td>2</td>
</tr>
<tr>
<td>Hypothalamic disorder</td>
<td>1</td>
</tr>
<tr>
<td>Aplastic anemia</td>
<td>1</td>
</tr>
<tr>
<td>Wegener’s disease</td>
<td>1</td>
</tr>
<tr>
<td>Unknown origin</td>
<td>3</td>
</tr>
<tr>
<td>Developmental dysplasia of the hip</td>
<td>7</td>
</tr>
<tr>
<td>Multiple epiphyseal dysplasia</td>
<td>2</td>
</tr>
<tr>
<td>Legg-Calve´-Perthes disease</td>
<td>6</td>
</tr>
<tr>
<td>Ankylosing spondylitis</td>
<td>5</td>
</tr>
<tr>
<td>Morquio’s disease</td>
<td>2</td>
</tr>
<tr>
<td>Ankylosis of unknown origin</td>
<td>2</td>
</tr>
<tr>
<td>Polycystic disease of the femoral head of unknown origin</td>
<td>2</td>
</tr>
<tr>
<td>Arthritis and osteomyelitis</td>
<td>2</td>
</tr>
<tr>
<td>Posttraumatic osteoarthritis</td>
<td>1</td>
</tr>
<tr>
<td>Psoriatic arthritis</td>
<td>1</td>
</tr>
</tbody>
</table>

A posterolateral approach was used in all hips without a trochanteric osteotomy. Acetabular defects were classified according to system of the American Academy of Orthopaedic Surgeons (AAOS) Committee on the Hip\(^6\). A Type I defect was seen in five hips, a Type II defect in 16 hips, and a Type III defect in eight hips. A metal
mesh was used in 14 hips to reconstruct a segmental defect. The remaining cavitary defect was reconstructed with bone impaction grafting. This technique has been reported in detail\textsuperscript{25}. Twenty-nine of the 69 hips had acetabular impaction grafting using femoral head autografts in 23 hips. Fresh-frozen, nonirradiated femoral head allografts were used in three hips with a Type III defect, using one or two femoral heads. In three hips, both autografts and an allograft femoral head were used. Second-generation cementing technique was applied in all hips. All patients received systemic prophylactic antibiotics (2 g cefazolin) immediately before surgery.

Several types of femoral and acetabular components were used (Table 2). Sizes of femoral heads used were 22 mm (9 hips), 28 mm (49 hips) and 32 mm (11 hips). Before 1989, Palacos\textsuperscript{®} bone cement (Merck, Darmstadt, Germany) was used and Surgical Simplex\textsuperscript{®} (Stryker) from 1989 on.

<table>
<thead>
<tr>
<th>Table 2: Types of implant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of acetabular implant</strong></td>
</tr>
<tr>
<td>Stryker Exeter\textsuperscript{TM}</td>
</tr>
<tr>
<td>Depuy Elite\textsuperscript{TM} Plus LPW</td>
</tr>
<tr>
<td>Zimmer Müller\textsuperscript{®}/Allopro\textsuperscript{®}</td>
</tr>
</tbody>
</table>

Postoperatively all patients had prophylactic anticoagulation therapy for 6 weeks or 3 months after surgery. Indomethacin was administered for 7 days to prevent heterotopic ossification. After 24 hours, passive movements were allowed, followed by ambulation with partial weightbearing with two crutches. After 6 weeks, full weightbearing was allowed. Patients with an acetabular bone graft had a slightly altered protocol, allowing touch weightbearing during the first 6 weeks and from 6 to 12 weeks partial weightbearing allowing 50% of body weight. Patients with extensive acetabular reconstructions initially had a 6-week period of bed rest. Patients were assessed clinically and radiographically at 6 and 12 weeks, at 6 months, at 1 year, and annually or biannually thereafter. The Harris hip score (HHS)\textsuperscript{13} and the Oxford Hip Questionnaire Score (OHQS)\textsuperscript{7} were used for clinical evaluation. Based on preoperative radiographs and the surgical reports, acetabular defects were classified according to the system of the AAOS Committee on the Hip\textsuperscript{6}.

Three of us (VB, RK, BWS) independently reviewed serial radiographs to
determine the structural quality of the bone graft, radiolucencies and osteolysis, prosthesis migration, socket tilting, and heterotopic ossification. Graft incorporation was defined as the manifestation of a regular radiodensity and trabecular bone structure throughout the graft and host bone with a continuous trabecular pattern according to Conn et al.\textsuperscript{5}. Radiolucent lines more than 2 mm wide were described and were defined as stable or as progressive in time. Acetabular zones were identified using the criteria of DeLee and Charnley\textsuperscript{8} and a radiographic failure was defined as radiolucent lines in all three zones and/or migration of 5 mm or more in any direction on the AP-pelvic view relative to the interteardrop line. Radiolucent zones on the femoral side were evaluated using the method of Gruen et al.\textsuperscript{11}. Loosening of the femoral component was defined using the criteria of Harris et al.\textsuperscript{14}. Definite loosening of the stem was defined as the appearance of a radiolucent line in all Gruen zones that did not exist on the immediate postoperative radiographs, a crack in the cement or fracture of the stem. Femoral prosthetic subsidence was considered abnormal if it was more than 2 mm\textsuperscript{18}. Heterotopic ossification was classified according to Brooker et al.\textsuperscript{1}. Followup radiographs were complete for 68 of the 69 hips; for one patient (one hip), a recent radiograph was not available due to her pregnancy at the time of review.

Kaplan-Meier survivorship analysis was performed for the whole group, as well as for hips with and without acetabular bone impaction grafting. End points used were revision of one or both components for any reason and revision for aseptic loosening and radiographic loosening. The log-rank test was used to compare survival of the bone impaction group and the non-bone impaction group.

Results

Survivorship of the total group was 90\% (95\% CI, 77\%–96\%) at 10 years with revision for aseptic loosening as the end point (Fig. 1) (Table 3). With revision for aseptic loosening as the end point, the primary cemented cups had a survivorship of 87\% (95\% CI, 68\%–95\%) and the bone impaction group 95\% (95\% CI, 72\%–99\%) at 10 years (Fig. 2). No differences in survival between the primary cemented and the bone impaction group were found. Eight hips had been revised. Three hips were revised because of septic loosening at 5.7, 7.3, and 7.8 years after the index
Cemented total hip arthroplasty in very young patients

Fig. 1
A Kaplan-Meier curve shows survivorship for the total group with revision for aseptic loosening as the end point. Dotted lines indicate 95% confidence intervals.

Fig. 2
A Kaplan-Meier curve shows survivorship for the bone impaction group (solid line) and the primary cemented group (dotted line) with revision for aseptic loosening as the end point.
operation. In five hips, only a revision of the cup was performed because of aseptic loosening after 2.3, 3.1, 4.1, 5.0 and 8.6 years. Two revised cases had impaction grafting of which one patient had primary diagnosis juvenile rheumatoid arthritis. No additional stem revisions were performed.

### Table 3: Survivorship for different categories of patients

<table>
<thead>
<tr>
<th>Category of patients</th>
<th>10-year survivorship in % (95% CI)</th>
<th>End point revision for aseptic loosening</th>
<th>End point revision for any reason</th>
<th>End point radiographic failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary cemented hips</td>
<td>87 (68–95)%</td>
<td>80 (59–90)%</td>
<td>87 (67–95)%</td>
<td></td>
</tr>
<tr>
<td>Acetabular bone impaction grafting</td>
<td>95 (72–99)%</td>
<td>89 (62–97)%</td>
<td>95 (72–99)%</td>
<td></td>
</tr>
<tr>
<td>All patients</td>
<td>90 (77–96)%</td>
<td>83 (69–92)%</td>
<td>89 (77–95)%</td>
<td></td>
</tr>
</tbody>
</table>

The mean HHS of the 57 surviving hips in 37 living patients was 89 (range, 55–100) and the mean OHQS was 19 (range, 12–42) after a minimum followup of 2 years (mean, 8.4 years; range, 2–18 years). One patient with juvenile arthritis had a HHS of 55 and an OHQS of 42 and was limited in walking distance, unable to climb stairs, and experienced moderate pain.

Progressive acetabular radiolucent lines were seen in six of the 61 surviving hips: in one zone in four hips and in two zones in two hips. Osteolysis was evident in three hips and limited to one zone in two cases; the third case involved two zones. Socket migration of more than 10 mm had occurred in one hip. Tilting of the acetabular component was seen in two patients, of which one was progressive the latest years of followup. Heterotopic ossification was seen in 14 of the 61 surviving hips and was classified as Grade II (11 hips) and Grade III (three hips). In THAs with bone impaction grafting, incorporation of the graft was seen in all hips (Fig. 3). None of the femoral components migrated more than 2 mm. A radiolucent line with an osteolytic lesion was seen in one hip in Gruen Zone 7; none of the surviving femoral components had evidence of radiographic loosening. One cup was considered loose, but revision has not been performed yet because of absence of complaints.

One patient (one hip) underwent an early reoperation due to suspicion of infection but recovery was complete after débridement and antibiotics. Two patients
Cemented total hip arthroplasty in very young patients

Fig. 3A–C

(A) A preoperative radiograph shows the hips of a 29-year-old woman with bilateral secondary osteoarthritis due to Bechterew’s disease who had the longest followup in our series.

(B) A postoperative radiograph shows the hips after bilateral reconstruction of the acetabulum with bone impaction grafting for a cavitary defect and a cemented prosthesis.

(C) A radiograph at 17 and 18 years after the reconstruction shows incorporation of the bone graft and no signs of loosening except for an acetabular radiolucent line at the right hip in zone III.
had a traumatic dislocation of the prosthesis, and closed reduction was successful in one, but for the other operative repositioning was needed. In one patient exploration of the femoral nerve was performed because of neurological deficit. The proximal part of the nerve could not be detected and recovery was incomplete. All eight revisions were performed in our own institute and all patients were followed after their revision. In seven hips, acetabular reconstruction with bone impaction grafting at revision surgery was performed and a cemented cup was placed. In two of the three revisions of the stem, reconstruction of a femoral defect was necessary using femoral bone impaction grafting and a cemented Exeter™ stem was inserted. For the eight revised hips the mean postoperative HHS was 88 (range, 41–100) and the mean postoperative OHQS of 20 (range, 12–54) at a minimum followup of 1 year (average, 4.5 years; range, 1–10 years).

Discussion

Degenerative cartilage disease of the hip in very young patients is often secondary to an underlying disease. Several options are available to deal with acetabular defects in young patients. The most used is an uncemented cup and if necessary a reinforcement ring, placed with or without bone grafts. Since 1979 we have preferred to reconstruct very young patients with a cemented THA, and in case of bone deficiencies, bone impaction grafting in combination with a cemented prosthesis. The purpose of our study was to (1) determine survival of the prosthesis in patients younger than 30 years and whether differences exist between hips placed with and without acetabular bone impaction grafting; (2) determine the clinical outcome of the surviving hips; (3) define radiological failures; and (4) determine complications and current state of revisions.

We draw the reader’s attention to several limitations. First is the use of multiple implant designs; however, all types were cemented. As a referral center, we have not referred cases to other hospitals and therefore we have included all diagnoses and acetabular bone defects during the time of the study except those who had an implant placed for tumors. Apart from the different implants there was no selection bias since we used the same treatment protocol in all patients, and in case of bone stock deficiencies, we reconstructed the defect with bone impaction grafting. Further, no
patients lost to followup, and we therefore believe our data are reliable. Second, our study had a relatively large group (26%) of patients with juvenile rheumatoid arthritis. These patients are probably less active compared to the other patients with a localized osteoarthritis of the hip in our series. In the literature, not all studies have the same conclusion relative to the outcome of THAs in rheumatoid arthritis, and in some studies, the outcome of this subgroup has reportedly worse outcomes relative to other plain osteoarthritic cases. Third, criteria for graft incorporation are difficult to define but Conn et al. stated that graft incorporation was defined as the manifestation of a regular radiodensity and trabecular bone structure throughout the graft and host bone with a continuous trabecular pattern. In the present series, acetabular bone grafting had been performed in 29 out of 69 cases and incorporation of the grafts was seen in all cases on a consensus base by three of the authors. The criteria used are still in debate in our department and future research has to bring more detailed criteria.

Our standardized treatment protocol was associated with a 10-year survival rate of 90% (95% CI, 77%–96%). Especially in young patients, we need techniques and implants with a proven long-term survival, and apart from a series of patients with exclusively juvenile chronic arthritis, there is limited literature regarding the survivorship and complications of THA surgery in patients younger than 30 years. For the acetabular side, Torchia et al. reported a revision rate for the cemented acetabular component of 43% at an average followup of 12.6 years. Sochart and Porter reported an acetabular rate of revision for cemented cups of 30% at a mean followup of 20 years. Maric and Haynes described a group of 17 hips, including four uncemented hips, and reported that 6% of the acetabular components were revised after an average followup of 9.3 years. We found a rate of revision of 11.6% for the acetabular component at a mean followup of 8.4 years.
Table 4.
Literature* of THA in patients 30 years or younger at the time of operation

<table>
<thead>
<tr>
<th>Study</th>
<th>No. hips</th>
<th>No. patients</th>
<th>Mean age in years (range)</th>
<th>Mean followup in years (range)</th>
<th>Survivorship/revised hips for all reasons (% of total)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cemented</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cage et al. [2]</td>
<td>22</td>
<td>17*</td>
<td>18.4 (15–21)</td>
<td>10.6 (8–15)</td>
<td>1 (4.5%)</td>
</tr>
<tr>
<td>Chandler et al. [3]</td>
<td>33</td>
<td>29</td>
<td>28 (19–35)</td>
<td>5.6 (4.8–7)</td>
<td>7 (21%)</td>
</tr>
<tr>
<td>Chmell et al. [4]</td>
<td>66</td>
<td>39</td>
<td>19.9 (11–29)</td>
<td>15.1 (11–22)</td>
<td>70% at 15 yrs (acetabular revision)</td>
</tr>
<tr>
<td>Halley and Charnley [12]</td>
<td>68</td>
<td>39</td>
<td>25.9</td>
<td>3.3 (0.5–8)</td>
<td>NR**</td>
</tr>
<tr>
<td>Sochart and Porter [29]</td>
<td>83</td>
<td>55</td>
<td>24.9 (17–29)</td>
<td>20 (5–30)</td>
<td>89% at 10 yrs; 65% at 25 yrs</td>
</tr>
<tr>
<td>Torchia et al. [30]</td>
<td>63</td>
<td>50</td>
<td>17 (11–19)</td>
<td>12.6 (1.6–18.6)</td>
<td>73% at 10 yrs; 55% at 15 yrs</td>
</tr>
<tr>
<td>Witt et al. [32]</td>
<td>96</td>
<td>54</td>
<td>16.7 (11–27)</td>
<td>11.5 (5–18)</td>
<td>24 (25%)</td>
</tr>
<tr>
<td>Busch et al. [current study]</td>
<td>69</td>
<td>48</td>
<td>24.6 (16–29)</td>
<td>8.4 (2–18)</td>
<td>83% at 10 yrs</td>
</tr>
<tr>
<td><strong>Uncemented</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kumar and Swann [17]</td>
<td>25</td>
<td>16</td>
<td>24.9 (15–39)</td>
<td>4.5 (1–19)</td>
<td>3 (12%)</td>
</tr>
<tr>
<td>Odent et al. [23]</td>
<td>62</td>
<td>34</td>
<td>18.3 (12–31)</td>
<td>6 (3–13)</td>
<td>90.1% at 13 yrs</td>
</tr>
<tr>
<td>Wangen et al. [31]</td>
<td>49</td>
<td>44</td>
<td>25 (15–30)</td>
<td>13 (10–16)</td>
<td>24 (49.0%)</td>
</tr>
<tr>
<td>McCullough et al. [31]</td>
<td>42</td>
<td>25</td>
<td>21 (11–35)</td>
<td>11.2 (8–13)</td>
<td>71% at 13 yrs</td>
</tr>
<tr>
<td><strong>Combined techniques</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kitsoulis et al. [16]</td>
<td>20</td>
<td>10</td>
<td>15.8 (13–24)</td>
<td>9.2 (2–20)</td>
<td>2 (10%)</td>
</tr>
<tr>
<td>Maric and Haynes [19]</td>
<td>17</td>
<td>17</td>
<td>18 (14–20)</td>
<td>9.3 (4.5–17)</td>
<td>2 (12%)</td>
</tr>
<tr>
<td>Dudkiewicz et al. [9]</td>
<td>69</td>
<td>56</td>
<td>23.2 (14–29)</td>
<td>7.4 (2–23)</td>
<td>14 (20%)</td>
</tr>
</tbody>
</table>

**Abbreviations:**
* Literature reported until July 2009.
* mixed group of patients with total hip and total knee prosthesis.
** not reported.

We believe our protocol with bone impaction grafting is a biologically attractive approach, resulting in restoration of bone stock in these young patients. This can be a great advantage for future revisions, as can be expected in these young patients. We included in our data all patients who underwent revision and found reasonable functional scores except in one case. This study reflects our large experience with this technique over a period of 16 years. Of the 130 total hip arthroplasties we perform every year, we have annually treated fewer than five patients younger than 30 years.
and only after intensive discussion and patient consent. Keeping in mind the high failure rates associated with increased demands within this cohort we think a cautious approach of these young patients is important.

Our results of cemented THA in patients younger than 30 years show a 10-year survival rate of 90% with end point revision for aseptic loosening. Loosening was mainly seen on the acetabular side and in case of an acetabular defect we recommend biological reconstruction using bone impaction grafting.

Acknowledgments

We thank Jan Hendriks for his statistical support.
References


Cemented total hip arthroplasty in very young patients
Chapter 4

Outcome of acetabular impaction bone grafting in patients under 50 years

Acetabular reconstruction with impaction bone-grafting and a cemented cup in patients younger than fifty years old

Schreurs BW
Busch VJ
Welten ML
Verdonschot N
Slooff TJ
Gardeniers JW

Abstract

Background: Acetabular bone deficiency can present a challenge during total hip arthroplasty, especially in young patients.

Questions/purposes: The purpose of the present study was to evaluate the long-term clinical and radiographic outcomes of primary and revision acetabular reconstruction with use of an impaction bone-grafting technique and a cemented polyethylene cup in young patients who had preexisting acetabular bone deficiency.

Methods: Forty-two consecutive acetabular reconstructions were performed in thirty-seven patients who were younger than fifty years old (average, 37.2 years old). The impaction bone-grafting technique was used for twenty-three primary and nineteen revision acetabular reconstructions. Twenty-eight patients (thirty-one hips) were available for review after a minimum duration of follow-up of fifteen years. Clinical and radiographic results were assessed, and survivorship analysis was performed with the Kaplan-Meier method.

Results: Eight hips were revised at a mean of twelve years (range, three to twenty-one years) after a primary reconstruction (four hips) or revision reconstruction (four hips). The revision was performed because of aseptic loosening of the acetabular component in four hips and because of culture-proven septic loosening in two. Two additional cups (both in hips that had had a revision reconstruction) were revised, during revision of the femoral stem, because of wear (one hip) or because of persistent intraoperative instability (one hip). Twenty-eight hips (in twenty-five patients) had retention of the acetabular component for a minimum of fifteen years. The mean Harris hip score for that group was 89 points. Twenty-six of these twenty-eight hips had no or slight pain. Kaplan-Meier analysis revealed a twenty-year survival rate of 80% (95% confidence interval, 67% to 94%) with acetabular revision for any reason as the end point and of 91% (95% confidence interval, 80% to 100%) with acetabular revision because of aseptic loosening as the end point.

Conclusions: Acetabular reconstruction with use of impaction bone-grafting and a cemented polyethylene cup is a reliable and durable technique that is associated with good long-term results in young patients with acetabular bone-stock defects.
Background

Despite improvements in cementing techniques, the reported rates of failure of cemented acetabular components in young patients are still high\(^1\)\(^-\)\(^4\). Since 1979, we have used impacted morselized cancellous bone graft and a cemented polyethylene cup to reconstruct the acetabulum during both primary and revision procedures in patients who have a loss of acetabular bone stock\(^5\). The goal of restoring lost bone is especially attractive when managing younger patients\(^6\). In 2001, we reported the results of forty-two acetabular reconstructions that had been performed with impaction bone-grafting in this same cohort of patients who, at that point, had been followed for ten to eighteen years\(^7\). The current study extends that follow-up to fifteen to twenty-three years after surgery.

Materials and Methods

Between July 1979 and December 1987, we performed an average of 220 primary total hip arthroplasties per year. For all primary arthroplasties in patients without loss of acetabular bone stock, our practice is to use cemented components and not to use bone graft. During this time-period, we performed forty-two consecutive acetabular reconstructions with use of an impaction bone-grafting technique and a cemented polyethylene cup in thirty-seven patients with deficient acetabular bone stock who were younger than fifty years old. This was the only technique used in our department to treat acetabular bone stock loss. We reviewed all reconstructions (twenty-three of which had been performed during primary total hip arthroplasty and nineteen of which had been performed during revision total hip arthroplasty) after a minimum duration of follow-up of fifteen years after surgery. Six different surgeons, including two of the authors (T.J.H.S. and J.W.M.G.), performed the reconstructions. The study group included fifteen men and twenty-two women who had an average age of thirty-seven years and two months (range, twenty to forty-nine years) at the time of the operation. One patient (one hip) was lost to follow-up, and four patients (five hips) died before the final review.
Indications

Primary Acetabular Reconstructions

Twenty-three primary acetabular reconstructions were performed in nineteen patients who had a loss of acetabular bone stock. The diagnosis was primary osteoarthritis in two hips, rheumatoid arthritis in eleven, and secondary osteoarthritis in ten. The causes of secondary osteoarthritis included congenital dislocation (three hips), avascular necrosis of the femoral head (two), tuberculous arthritis (two), posttraumatic arthritis (two), and ankylosing spondylitis (one).

Revision Acetabular Reconstructions

The indication for all nineteen acetabular revisions (in eighteen patients) was aseptic loosening. Thirteen revisions were performed at the site of a previous total hip arthroplasty, and six were performed at the site of a previous resurfacing arthroplasty. The diagnosis at the time of the primary procedure had been osteonecrosis of the femoral head (five hips), epiphysiolysis (four), congenital dislocation of the hip (two), rheumatoid arthritis (three), ankylosing spondylitis (two), protrusio acetabuli (one), tuberculous arthritis (one), and a bleeding disorder due to hemophilia (one).

Classification of Acetabular Defects

With use of the preoperative and immediate postoperative anteroposterior pelvic radiographs and the operative reports, the acetabular defects were classified on a consensus basis by three of the authors (B.W.S., T.J.J.H.S., and V.J.J.F.B.) according to the system of the American Academy of Orthopaedic Surgeons Committee on the Hip. A segmental (type-I) defect was seen in one hip that was undergoing a primary procedure, a cavitary (type-II) defect was seen in twenty-seven hips (including sixteen that were undergoing a primary procedure and eleven that were undergoing a revision), and a combined (type-III) defect was seen in fourteen hips (including six that were undergoing a primary procedure and eight that were undergoing a revision).

Surgical Technique

The posterolateral approach without trochanteric osteotomy was used in all cases. For all reconstructions, the grafts were morselized with a rongeur and cancellous bone chips with a diameter of 0.7 to 1.0 cm were created. This technique has been described in detail.
Primary Acetabular Reconstructions
After resection of the femoral head, the acetabulum was reamed and all cartilage was removed. Our goal was to create a bleeding trabecular bone bed, and any segmental wall defects were closed. The femoral head was the source of the autograft for twenty of the twenty-three primary total hip arthroplasties, and an autogenous bone from the iliac crest was used for the other three.

Revision Acetabular Reconstructions
After removal of the failed components, interface tissue was sent for frozen-section analysis to rule out infection. On the basis of these results, a two-stage revision procedure was performed in two patients (Cases 30 and 35; see Appendix) for the treatment of suspected septic loosening. The acetabulum was reamed to create a bleeding trabecular bone bed. Segmental defects in the medial wall or peripheral defects of the acetabulum were closed with a slice of corticocancellous bone or with metal mesh. In four hips undergoing revision at the site of a failed resurfacing arthroplasty, we used the femoral head (two hips) or bone from the iliac crest (two hips). In two other such hips, autogeneous bone from the iliac crest was combined with a femoral head allograft. In the thirteen hips undergoing revision at the site of a failed total hip arthroplasty, we used fresh-frozen femoral head allograft, which has been our practice since 1984.

Both Primary and Revision Reconstructions
During both primary and revision arthroplasties, any remaining sclerotic areas were perforated with multiple 2-mm drill-holes, the bone bed was cleaned with use of lavage, and impaction bone-grafting was performed. A trial acetabular prosthesis and a mallet were used to distribute and impact the bone grafts. A goal of impaction grafting was to restore the original center of rotation of the hip, with the level of the transverse ligament used as a reference. The last trial prosthesis that was used for impaction was at least 2 mm larger than the proposed cup in order to allow for a cement mantle of sufficient thickness. In thirty-two hips, a thin Vitallium wire mesh (Mecron, Berlin, Germany) was used on top of the graft reconstruction. After pressurization of the bone cement, a 32-mm all-polyethylene cup was inserted. A Müller cup was used in twenty-five hips, and an Allopro cup was used in the remaining seventeen hips (Sulzer, Wintherthür, Switzerland). Regular bone cement was used for the primary arthroplasties, whereas gentamicin-impregnated cement (Palacos R or Palacos R with gentamicin; Merck, Darmstadt, Germany) was used for the revisions.
Postoperative Regimen

Postoperative treatment for all patients included bed rest for six weeks, systemic administration of antibiotics for five days, administration of indomethacin as prophylaxis against heterotopic ossification for seven days, and oral anticoagulation therapy for three months. Passive exercises were allowed after twenty-four hours, followed by walking with partial weight-bearing after six weeks and full weight-bearing after three months.

Follow-up

At the time of the final review, one patient (Case 4; see Appendix) had been lost to follow-up. Two patients who had been lost to follow-up at the time of the previous report were found and were included in this study. Four patients (five hips) (Cases 2, 14, 15, 22, and 33; see Appendix) died from causes that were unrelated to the operation at 4.3, 5.4, 9.0, and 15.4 years postoperatively. All of the patients who died had been followed on a regular basis until death and were included in the present study, but a Harris hip score from the time just prior to death was not available. None of them, however, had had a reoperation or a revision. All of the living patients with surviving hips returned for a clinical and radiographic examination, with the exception of two patients whose radiographs were sent from other clinics and whose hip scores were obtained by telephone. In the case of one patient, the hip score was incomplete at the time of the latest visit, so an update was performed by telephone. Preoperative Harris hip scores were not known.

Radiographic Follow-up

Serial anteroposterior and lateral radiographs were reviewed to determine the extent of incorporation of the graft, the presence of radiolucent lines, migration of the cup, and the formation of heterotopic ossification. Radiographic data were complete for thirty-eight hips, which were used for further analysis. The radiographic data were incomplete for two patients (three hips) and missing for one patient (Case 4; see Appendix) who had been lost to follow-up. The graft was considered to be incorporated when the graft and the host bone were of equal radiodensity, with a continuous trabecular pattern throughout. Zones of radiolucency were assessed on the anteroposterior radiographs with the method of DeLee and Charnley, with a radiolucent line measuring 2 mm in width considered to be a positive finding.
Radiolucent lines were defined as stable or as progressive over time. Heterotopic ossification was classified according to the system of Brooker et al.\textsuperscript{12}.

**Survivorship Analysis**

Kaplan-Meier survivorship analysis was performed for the entire group of hips treated with acetabular reconstruction as well as for the subgroups of hips treated with primary and revision acetabular reconstruction. The survivorship analysis was performed with three different end points: revision of the acetabular component for any reason, revision of the acetabular component for aseptic loosening, and radiographic signs of failure (defined as a radiolucent line in all three zones or migration of the acetabular component of ≥5 mm in any direction relative to the interteardrop line as seen on the anteroposterior pelvic radiograph).

**Results**

**Clinical Results (see Appendix)**

Twenty-eight hips (in twenty-five living patients) that had retention of the index prosthesis were followed for a mean of 17.5 years (range, fifteen to twenty-three years). The average Harris hip score in this group was 89 points (range, 60 to 100 points). Twenty-six of these twenty-eight hips had no or slight pain. Two hips (Cases 17 and 34; see Appendix) with Harris hip scores of 64 and 60 points had moderate and mild pain, respectively.

**Primary Acetabular Reconstructions**

Twenty-three primary reconstructions were performed in nineteen patients for the treatment of a type-1 defect (one hip), a type-2 defect (sixteen hips), or a type-3 defect (six hips). Four hips required acetabular revision. One hip with a type-3 defect (Case 19; see Appendix) was revised because of culture-proven septic loosening 14.5 years after the index operation. Three hips (Cases 3, 21, and 23; see Appendix), including one with a type-2 defect and two with a type-3 defect, were revised because of aseptic loosening 6.4, 15.3, and 20.5 years after the index operation.
Revision Acetabular Reconstructions

Nineteen revision reconstructions were performed in eighteen patients for the treatment of a type-2 defect (eleven hips) or a type-3 defect (eight hips). Four hips were rerevised. One hip with a type-2 defect (Case 28; see Appendix) was rerevised three years after the index operation because of culture-proven septic loosening. One hip with a type-3 defect (Case 41; see Appendix) was rerevised 11.7 years after the operation because of aseptic loosening. Another hip with a type-3 defect (Case 37; see Appendix) was rerevised 12.3 years after surgery. In that case, a femoral revision had been planned for the treatment of osteolysis and pain. Intraoperatively, however, the hip was very unstable after isolated revision of the stem and therefore the original well-fixed cup was exchanged in order to correct the instability. Another hip with a type-2 defect (Case 30; see Appendix) was rerevised nine years after the operation because of recurrent dislocation and wear of the cup.

Cavitary Defects Compared With Combined Defects

Acetabular reconstruction was performed in twenty-seven hips with a cavitary (type-2) defect and fourteen hips with a combined (type-3) defect. Of the eight hips in which the reconstruction failed, two (including one with a type-2 defect and one with a type-3 defect) were revised because of septic loosening and two (including one with a type-2 defect and one with a type-3 defect) were revised because of instability. Therefore, of the forty-one reconstructions, only four failed because of aseptic loosening, including one primary reconstruction in a hip with a cavitary (type-2) defect and one revision and two primary reconstructions in hips with a combined (type-3) defect.

Radiographic Results

Overall Results

Of the twenty-eight hips in twenty-five patients with the implant still in situ that were available for radiographic review at the time of the final follow-up, sixteen appeared to have a well-fixed implant, with uniform radiodensity of the graft and the host bone and without progressive radiolucent lines (Figs. 1-A, 1-B, and 1-C). None of the hips had pelvic osteolysis. Ten hips had periarticular heterotopic ossification: five hips had Brooker grade-I ossification, two hips had grade-II ossification, two hips had grade-III ossification, and one hip (Case 23; see Appendix) had grade-IV ossification. The hip with grade-IV ossification was asymptomatic.
Figs 1-A, 1-B, and 1-C
Radiographs of the hip of a forty-seven-year-old woman (Case 34; see Appendix) who underwent revision arthroplasty because of secondary osteoarthritis due to epiphysiolysis.

**Fig. 1-A**
Radiograph made before the index acetabular reconstruction, demonstrating loosening of the resurfacing prosthesis with creation of a cavitary acetabular defect.

**Fig. 1-B**
Radiograph made after reconstruction with impaction bone-grafting and a cemented cup, with use of Vitallium mesh to cover the graft. The use of metal mesh on top of the graft is not our current practice; for more than ten years, we have directly cemented the graft at the reconstruction site. The irregular structure of the graft can be seen.

**Fig. 1-C**
Radiograph made sixteen years postoperatively, showing no radiographic signs of loosening and good incorporation of the graft.
Primary Acetabular Reconstructions

Of the fifteen surviving hips that had undergone a primary reconstruction, three showed progressive radiolucent lines in one zone and two showed stable lines in one zone at the cement-bone interface. All four hips that were revised after a primary reconstruction (including one that was revised because of septic loosening and three that were revised because of aseptic loosening) showed complete loosening radiographically: three hips (Cases 3, 19, and 23; see Appendix) had progressive radiolucent lines in three zones, while the other hip (Case 21; see Appendix) had 6 mm of migration of the cup. In the three hips with aseptic loosening the radiolucent lines were seen at the cement-bone interface, whereas in the one hip with septic loosening the radiolucent lines were seen at the graft-host interface.

Revision Acetabular Reconstructions

Of the thirteen surviving hips that had undergone a revision reconstruction, one hip (Case 26; see Appendix) showed progressive radiolucent lines in three zones as well as 10 mm of vertical migration of the cup 17.3 years after surgery. This hip was considered to have failed radiographically, but it was not revised because the patient had only mild symptoms. Six other surviving hips showed progressive radiolucent lines in one zone, and two hips had progressive lines in two zones. Two hips that were rerevised because of septic and aseptic loosening (Cases 28 and 41; see Appendix) showed progressive radiolucent lines in three zones and were considered to have failed radiographically. Of the other two revised hips, the one that was revised because of wear (Case 30; see Appendix) showed a progressive radiolucent line in one zone and the one that was revised because of intraoperative instability after a femoral revision (Case 37; see Appendix) was not loose at all. In the hips with aseptic loosening, the radiolucent lines were seen at the bone-cement interface.

Additional Reoperations and Complications

In addition to the two femoral stem revisions already mentioned (Cases 30 and 37; see Appendix), two stems were revised because of aseptic loosening at six years (Case 26; see Appendix) and at twelve years (Case 27; see Appendix). During both reoperations, the acetabular cup was well fixed and was left in situ. In one patient (Case 17; see Appendix), periarticular ossifications were removed 1.2 years postoperatively. One patient (Case 26; see Appendix) had development of a neuropraxia of the peroneal nerve, which resolved fully.
**Survivorship Analysis**

*Overall Results*

With revision of the cup for any reason as the end point, the survival rate was 92% (95% confidence interval, 83.5% to 100%) at ten years, 83% (95% confidence interval, 71.7% to 95.7%) at fifteen years, and 80% (95% confidence interval, 67.2% to 93.5%) at twenty years. With revision of the cup for aseptic loosening as the end point, the survival rate was 97% (95% confidence interval, 92.1% to 100%) at ten years, 94% (95% confidence interval, 86.9% to 100%) at fifteen years, and 91% (95% confidence interval, 80.4% to 100%) at twenty years. With radiographic signs of loosening as the end point, the survival rate was 92% (95% confidence interval, 84% to 100%) at ten years and 89% (95% confidence interval, 80% to 99%) at fifteen years.

*Primary Acetabular Reconstructions*

With revision of the cup for any reason as the end point, the survival rate after primary acetabular reconstruction was 95% (95% confidence interval, 85% to 100%) at ten years, 88% (95% confidence interval, 73% to 100%) at fifteen years, and 82% (95% confidence interval, 63% to 100%) at twenty years (Fig. 2). With revision of the cup for aseptic loosening as the end point, the survival rate was 95% (95% confidence interval, 85% to 100%) at ten years, 95% (95% confidence interval, 85% to 100%) at fifteen years, and 87% (95% confidence interval, 71% to 100%) at twenty years. With radiographic signs of loosening as the end point, the survival rate was 89% (95% confidence interval, 75% to 100%) at fifteen years.

*Revision Acetabular Reconstructions*

With revision of the cup for any reason as the end point, the survival rate after revision acetabular reconstruction was 89% (95% confidence interval, 75% to 100%) at ten years, 78% (95% confidence interval, 59% to 97%) at fifteen years, and 78% (95% confidence interval, 59% to 97%) at twenty years (Fig. 3). With revision of the cup for aseptic loosening as the end point, the rate of survival was 100% at ten years, 93% (95% confidence interval, 82% to 100%) at fifteen years, and 93% (95% confidence interval, 82% to 100%) at twenty years. With radiographic signs of loosening as the end point, the rate of survival was 89% (95% confidence interval, 76% to 100%) at fifteen years.
Fig. 2
Kaplan-Meier curves (and 95% confidence intervals) showing the ten, fifteen, and twenty-year rates of survival following primary acetabular reconstruction with use of impaction bone-grafting, with revision for any reason and revision for aseptic loosening as the end points.

Fig. 3
Kaplan-Meier curves (and 95% confidence intervals) showing the ten, fifteen, and twenty-year rates of survival following revision acetabular reconstruction with use of impaction bone-grafting, with revision for any reason and revision for aseptic loosening as the end points.
Discussion

Soon after the introduction of modern total hip arthroplasty with cement, it became clear that replacements in young patients were associated with high rates of failure due to loosening and wear. Despite the introduction of second-generation cementing methods, which improved the rates of survival of the femoral component, the rate of failure of the acetabular component in young patients remained high. Ballard et al. reported that the rate of survival of cemented acetabular components in patients less than fifty years old was 76% at eleven years with revision because of aseptic loosening as the end point. Smith et al. reported that the cumulative rate of survival of cemented cups in young patients was 71% at eighteen years with revision because of aseptic loosening as the end point. With radiographic signs of loosening as the end point, the rate of survival of the cup in a mixed group of hips with metal-backed and all-polyethylene cups was 63% at eighteen years. Callaghan et al. reported that the rate of survival of cemented acetabular components in patients less than fifty years old was 76% at twenty-five years with revision because of aseptic loosening as the end point. However, the probability of survival of the acetabular component was only 54% (95% confidence interval, 41% to 67%) at twenty-five years when radiographic evidence of definite or probable loosening or revision for aseptic loosening was used as the end point. In the current study, the rate of survival of the cemented cup was 91% (95% confidence interval, 80.4% to 100%) at twenty years with revision because of aseptic loosening as the end point. We believe that the long-term results in this mixed group of primary and revision acetabular reconstructions are very acceptable and are at least comparable with those of previous series of primary reconstructions with cement.

Another option for acetabular revision is the use of a cementless acetabular component. Although such components are frequently used, long-term reports with a minimum of ten years of follow-up are scarce. Leopold et al. reported the results of 138 cementless acetabular revisions in 131 patients after an average duration of follow-up of 11.5 years. The rate of survival of the cup with re-revision for any reason as the end point was 89%, with fourteen of 130 hips having been rerevised; no cup was re-revised because of aseptic loosening. When all cups that had been lost to follow-up were considered as failures, as suggested by Murray et al., the worst-case scenario survival rate (including all acetabular re-revisions that had been performed
for any reason and all hips that had been lost to follow-up) was 84%. These data are comparable with the results for the revision group in the present study at the same follow-up interval. Templeton et al.\textsuperscript{26} reported on sixty-one consecutive revisions that were performed in fifty-five patients by one surgeon; all acetabular revisions were performed with a porous-coated Harris-Galante component. At the time of the review, none of the acetabular components had been re-revised because of aseptic loosening after a mean duration of follow-up of 12.9 years. However, eight (13%) of the sixty-one hips underwent additional procedures on the acetabulum during a reoperation and pelvic osteolysis was observed in 13% of the hips. Therefore, despite the very low rate of re-revision of the cementless metal shell for aseptic loosening, we believe that pelvic osteolysis will be the major problem as these uncemented cups are followed for longer periods.

To our knowledge, although the number of patients in the present study is not large, the long-term results reported here are among the most favorable that have been published to date in patients younger than fifty years old.\textsuperscript{2,3} The impaction bone-grafting technique is especially attractive for use in young patients with bone-stock deficiencies (in whom future revisions can be expected) because bone stock is restored and relatively normal hip mechanics can be achieved.

The strengths of the present study are that (1) we reviewed all consecutive reconstructions that had been performed before December 1987 with use of the impaction bone-grafting technique in young patients and (2) this was not a single-surgeon study. According to the criteria described by Murray et al.\textsuperscript{25}, the reliability of our study is high. The loss-to-follow-up quotient was 0.125, and the worst-case scenario survival rate (which is based on the number of rerevisions that were performed for any reason, with all hips that had been lost to follow-up being considered as failures) was 79% at an average of 17.5 years.

A possible limitation of our study is that fourteen of the reconstructions were performed in patients with rheumatoid arthritis, who theoretically are more sedentary than patients with osteoarthritis. While good results have been reported previously in association with the use of impacted morselized bone grafts in patients with protrusio acetabuli and rheumatoid arthritis,\textsuperscript{27-29} the results of total hip arthroplasty in a nationwide study of young patients with rheumatoid arthritis who were less than fifty-five years old was disappointing at longer durations of follow-up.\textsuperscript{30}
Although Conn et al.\textsuperscript{10} suggested radiographic criteria for graft incorporation, it is difficult to determine whether there is incorporation of morselized bone grafts on radiographs. Only a biopsy can demonstrate the incorporation. Heekin et al.\textsuperscript{31}, and recently van der Donk et al.\textsuperscript{6}, demonstrated that impacted morselized bone graft showed overall good incorporation with cement. In contrast, other investigators have observed that the incorporation of structural bone grafts is often incomplete\textsuperscript{32,33}. In the group of four hips in the present study that failed after a primary reconstruction, the bone stock at the time of revision was found to be satisfactory, with only one hip demonstrating worsening of the defect (from a cavitary defect to a combined defect). In the group of four hips that failed after a revision, no hip had progressive bone stock deficiency (two hips had a cavitary defect both at the time of the index procedure and at the time of revision, and the other two hips had a combined defect at both time-points). In all cases, acetabular reconstruction with bone graft was possible in combination with a standard acetabular implant.

The technique of performing acetabular impaction bone-grafting is demanding and has pitfalls. On the acetabular side, large trabecular bone chips with a diameter of between 0.7 and 1 cm should be used because smaller chips with a diameter of 0.2 to 0.5 cm will produce inferior cup stability\textsuperscript{34}. The chips that are produced by most commercial bone mills are too small for application in the acetabulum. Impaction of the bone grafts must be tight enough to create stability with use of a hammer and acetabular impactors. Compressing the grafts with an acetabular reamer in reverse also reduces initial cup stability\textsuperscript{34}. An optimal cementation technique is also essential, including pressurization of the cement with a seal before introduction of the cup.

According to our current postoperative protocol, these patients begin to walk on two crutches two days after surgery. For the first six weeks they are allowed toe-touch weightbearing, and for the next six weeks they are permitted to place 50% body weight on the affected hip with use of two crutches. However, the period of immobilization or restricted weightbearing should be adjusted in relation to the complexity of the defects and their reconstruction.
References


Outcome of acetabular impaction bone grafting in patients under 50 years
## Table E-1: Characteristics of Primary Total Hip Arthroplasties

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### Abbreviations:
- pOA = primary osteoarthritis
- sOA = secondary osteoarthritis
- RA = rheumatoid arthritis

*According to the system of the American Academy of Orthopaedic Surgeons.
†According to the system of the American Academy of Orthopaedic Surgeons.
‡1 = autograft.
§M = Mueller, A = Allopro.
#The follow-up is from the date of the index operation to the date of the latest radiographic study (or revision).
**1 = nonprogressive lines, 2 = progressive lines in one or two zones, 3 = progressive lines in three zones.
††Brooker classification. I = isolated ossification; II = ossification, interspace >1 cm; III = ossification, interspace <1 cm; IV = complete radiographic ankylosis.
Table E-2: Characteristics of Revision Total Hip Arthroplasties

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<td>Y</td>
<td>2.9</td>
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Abbreviations: *pOA = primary osteoarthritis, sOA = secondary osteoarthritis, RA = rheumatoid arthritis. †According to the system of the American Academy of Orthopaedic Surgeons. ‡Cav = cavitary defect, Seg = segmental defect, Com = combined defect. §M = Mueller, A = Allopro. #The follow-up is from the date of the index operation to the date of the latest radiographic study (or revision). **1 = nonprogressive lines, 2 = progressive lines in one or two zones, 3 = progressive lines in three zones. ††Brooker classification. I = isolated ossification; II = ossification, interspace >1 cm; III = ossification, interspace <1 cm; IV = complete radiographic ankylosis.
Chapter 5

Update of the study in Chapter 4, now with a unique long-term follow-up of 25 years after surgery

Acetabular reconstructions with impaction bone-grafting and a cemented cup in patients younger than fifty years old - A concise follow-up, at twenty to twenty-eight years, of a previous report.

Busch VJ
Gardeniers JW
Verdonschot N
Slooff TJ
Schreurs BW

*J Bone and Joint Surgery Am. 2011; 93: 367 - 71*
Abstract

Background: In a previous report we presented our results of forty-two acetabular reconstructions in thirty-seven patients under fifty years using impaction bone-grafting and a cemented cup at a minimum of fifteen years of follow-up.

Questions/purposes: What are the results of acetabular impaction bone-grafting and a cemented cup in young patients after twenty to twenty-eight years of follow-up?

Methods: We evaluated clinical and radiographic results and we performed survivorship analysis using the Kaplan-Meier method.

Results: Eight additional cups had to be revised, four because of aseptic loosening, three because of wear and one during a revision of the stem. Three additional cups were considered loose on radiographs. Survivorship of the acetabular reconstructions was 73% after twenty years and 52% after twenty-five years with revision for any reason as the end point. With revision for aseptic loosening as the end point, survival was 85% after twenty years and 77% after twenty-five years and for radiographic loosening, survival was 71% at twenty and 62% at twenty-five years.

Conclusions: Our previous results have declined but the technique using impacted morselized bone graft and a cemented cup is a useful technique to restore bone stock in young patients with acetabular defects requiring primary or revision total hip arthroplasty.
Background

Previously, we reported the clinical and radiographic outcomes of forty-two consecutive acetabular reconstructions performed with use of an impaction bone-grafting technique and a cemented cup in thirty-seven patients who were all younger than fifty years (average, thirty-seven years; range, twenty to forty-nine years) at the time of surgery. We used impaction bone-grafting as a biological technique to reconstruct acetabular deficiencies in younger patients. This reconstructive technique was used in twenty-three primary and nineteen revision operations. The average follow-up in that study was seventeen years and six months (range, fifteen to twenty-three years). Kaplan-Meier analysis showed that the probability of survival of the acetabular component at fifteen years was 83% (95% confidence interval, 72% to 96%) with the end point being revision of the cup for any reason and 94% (95% confidence interval, 87% to 100%) with the end point being revision of the cup for aseptic loosening. The overall radiographic survival rate of the cup was 89% (95% confidence interval, 80% to 99%) at fifteen years.

The purpose of the present study was to update the clinical and radiographic results of our previous report after a mean duration of follow-up of twenty-three years (range, twenty to twenty-eight years).

Methods

The study was approved by our institutional review board. Between July 1979 and December 1987, we performed forty-two consecutive acetabular reconstructions, with use of an impaction bone-grafting technique and a cemented polyethylene cup, in thirty-seven patients who had deficient acetabular bone stock and who were younger than fifty years at the time of the operation. It was the only technique used in our department to treat acetabular bone stock loss. After a posterolateral approach and resection of the femoral head or removal of failed components, the acetabulum was reamed to create a bleeding bone bed. Segmental defects were reconstructed with use of a metal mesh or a solid graft. Before impaction, remaining sclerotic areas were perforated with multiple 2-mm drill-holes. In primary acetabular reconstructions, the femoral head was morselized with a rongeur to create cancellous bone chips with
a diameter of 0.7 to 1.0 cm. In hips with larger defects or when revision surgery
was being performed, fresh-frozen nonirradiated femoral head allografts were used.
In some early cases, bone grafts were taken from the iliac crest. After lavage of
the acetabulum, the grafts were impacted with use of impactors and a mallet. The
defect was reconstructed, layer by layer, until the defect was restored completely.
Bone cement was pressurized into the impacted grafts with use of a seal. Before
1989, we used Palacos bone cement (Merck, Darmstadt, Germany), and, from
1989 on, we used Surgical Simplex bone cement (Stryker Howmedica, Newbury,
United Kingdom). Regular bone cement was used for the primary arthroplasties,
whereas gentamicin-impregnated cement was used for the revisions. To create a
sufficient cement mantle, the last trial prosthesis that was used for impaction was at
least 2 mm larger than the proposed cup. In the present series, twenty-five 32-mm
Müller and seventeen 32-mm Allopro all-polyethylene cups (Sulzer, Winterthur,
Switzerland) were used. Both components were manufactured from compression-
molded GUR 412 (RCH-1000; Ruhrchemie, Oberhausen, Germany) and sterilized
by gamma radiation in air. Sixteen cemented Charnley-Müller curved stems (Protek
AG, Bern, Switzerland), twenty-five cemented M.E. Müller straight stems (Protek
AG), and one cemented Stanmore prosthesis (Biomet, Bridgend, United Kingdom)
were used, all with a head size of 32 mm.

For this report, we reviewed all reconstructions (twenty-three [55%] primary
and nineteen [45%] revision total hip reconstructions) at a minimum period of
follow-up of twenty years. All patients were prospectively followed annually or
biennially for at least twenty years, or until revision or death.

Acetabular defects were classified according to the classification system of
the American Academy of Orthopaedic Surgeons (AAOS) Committee on the
Hip2 (Table I). Radiographic evidence of bone-graft incorporation was defined as
equal radiodensity of graft and host bone, with a continuous trabecular pattern
throughout, according to Conn et al.3. Radiolucent lines >2 mm wide were identified
in the three zones of DeLee and Charnley4. Radiolucent lines were defined as stable
or as progressive with time. As of the last review in 2008, all living patients with
surviving hips were seen for clinical and radiographic examination and both a Harris
hip score and an Oxford Hip Questionnaire Score5 were obtained. All patients who
died during the period of follow-up were followed on a regular basis until their
death, and their data were included in this report. Failure was defined clinically as
the need for revision of the acetabular component for any reason. A radiographic failure was defined as radiolucent lines in all three zones of DeLee and Charnley, or migration of 5 mm or more in any direction relative to the interteardrop line on the anteroposterior pelvic radiograph. Linear polyethylene wear was measured according to the method described by Livermore et al., and the measurements were corrected for magnification.

The Kaplan-Meier analysis was performed with three different end points: revision of the acetabular component for any reason, revision of the acetabular component for aseptic loosening, and radiographic signs of failure. Kaplan-Meier survivorship analysis was performed for the whole group of hips treated with acetabular reconstruction and included 95% confidence intervals. A log-rank test was used to compare survival rates of subgroups.

<table>
<thead>
<tr>
<th>Table 1: Patient demographics</th>
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<td>M</td>
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<tr>
<td>Type of defects according to AAOS classification</td>
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<td>Cavitary</td>
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<td>Lost to follow-up</td>
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<td>Revisions during follow-up</td>
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<tr>
<td>Due to septic loosening</td>
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<tr>
<td>Due to aseptic loosening</td>
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<tr>
<td>Due to wear</td>
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<td>During stem revision</td>
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</table>
Results

Clinical Results

Of the original group of thirty-seven patients (forty-two hips), one patient (one implant) was lost to follow-up and eight patients (ten implants) had died of causes unrelated to the surgery. At the time of the final review, nineteen surviving hips were in situ in seventeen patients and were clinically and radiographically evaluated after a mean follow-up period of twenty-three years (range, twenty to twenty-eight years). Unfortunately, one patient was unable to attend due to progressive dementia; however, her relatives reported no reoperation and no apparent clinical symptoms. For radiographic analyses for this patient, we used the last radiograph available, from 2005. The mean Harris hip score of the surviving hips was 88 (range, 44 to 100), and the mean Oxford Hip Questionnaire Score was 20 (range, 12 to 41).

Revisions

Eight additional cups (19.5%) had to be revised after the previous report, which meant that sixteen acetabular revisions (39%) were performed overall. Two cups (4.9%) were revised because of culture-proven septic loosening after three and 14.5 years. Eight reconstructions (19.5%) failed because of aseptic loosening and were revised after a mean of 17.3 years (range, 6.4 to 25.5 years), including four with a cavitary (type-2) defect and four with a combined (type-3) defect. Four reconstructions (9.8%) were revised because of wear and osteolysis after a mean of 18.8 years (range, 8.9 to 25.4 years). Two cups (4.9%) were revised after 12.3 and 18.3 years during a revision of the stem because of persistent instability and matching problems. However, these six cups were both intraoperatively and radiographically well-fixed.

Radiographic Results

Follow-up radiographs were complete for thirty-seven hips (90.2%), which were used for further analysis. Data were incomplete for two deceased patients (three hips) and for the patient with dementia, for whom the latest radiograph was used. Of the nineteen hips in seventeen patients with the implant still in situ, twelve cups appeared to be well fixed with uniform radiodensity of the graft and the host bone and without progressive radiolucent lines. Three cups (7.3%) were considered loose radiographically. The radiographs of four additional hips showed progressive
radiolucent lines (in zone three in three hips, and in zones two and three in one hip). The radiograph of one hip showed a pelvic osteolytic area in zone one. Six hips had Brooker grade-I ossification, one hip had Brooker grade-II ossification, and three hips had Brooker grade-III ossification. The mean polyethylene wear for the whole group of living patients with the implant still in situ was 2.0 mm (0.8 to 3.4 mm).

Of the six surviving hips in five deceased patients, one cup showed a progressive radiolucent line in one zone. Of the sixteen revised hips, ten showed definitive radiographic loosening of the cup. Four cups showed excessive polyethylene wear, and one of the four had associated pelvic osteolysis but migration or progressive lines in more than one zone were not seen. The remaining two cups were revised during revision of the stem and did not show progressive radiolucent lines. The mean wear of the revised cups measured 2.1 mm (range, 0 to 4.2 mm).

**Additional Reoperations and Complications**

As noted in our previous report, four revisions of the femoral component were done and, in one patient, periarticular ossifications were removed 1.2 years postoperatively. Since the time of our previous report, there has been one additional femoral revision for aseptic loosening, and the cup was revised during the same operation. Neurapraxia of the peroneal nerve developed postoperatively in one patient but fully resolved.

**Survivorship Analysis**

Survivorship of the acetabular reconstructions according to the different end points is shown in Table II. With revision for any reason as the end point, survival of the acetabular component was 73% (95% confidence interval, 58% to 87%) at twenty years and 52% (95% confidence interval, 35% to 72%) at twenty-five years (Fig. 1). With revision for aseptic loosening of the cup as the end point, survivorship was 85% (95% confidence interval, 72% to 97%) at twenty years and 77% (95% confidence interval, 62% to 92%) at twenty-five years of follow-up. With radiographic loosening of the cup as the end point, the survivorship was 71% (95% confidence interval, 55% to 86%) at twenty years and 62% (95% confidence interval, 44% to 80%) at twenty-five years. Comparison of survival rates of primary and revision reconstructions did not reveal any statistical differences.
Table 2: Survival rates for the different periods of follow-up and end points

<table>
<thead>
<tr>
<th>End point for survivorship of reconstructions</th>
<th>15-year survival (95% Confidence Interval)</th>
<th>20-year survival (95% Confidence Interval)</th>
<th>25-year survival (95% Confidence Interval)</th>
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<tr>
<td>Revision for any reason</td>
<td>0.84 (0.72 to 0.96)</td>
<td>0.73 (0.58 to 0.87)</td>
<td>0.52 (0.35 to 0.72)</td>
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<tr>
<td>Aseptic loosening</td>
<td>0.94 (0.87 to 1.00)</td>
<td>0.85 (0.72 to 0.97)</td>
<td>0.77 (0.62 to 0.92)</td>
</tr>
<tr>
<td>Radiographic loosening</td>
<td>0.89 (0.80 to 0.99)</td>
<td>0.71 (0.55 to 0.86)</td>
<td>0.62 (0.44 to 0.80)</td>
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</table>

Fig. 1 Kaplan-Meier survival curve for the entire group (black line) and the upper and lower 95% confidence intervals (gray lines), with revision of the acetabular component for any reason as the end point.
Conclusions

The technique of impaction bone-grafting is especially attractive for the purpose of obtaining a biological repair of the acetabular bone defect and facilitating future revisions in young patients. The follow-up was nearly complete in our study, and the fate of every reconstruction is known, except in one case. Probably due to the relatively small numbers, statistical differences could not be shown between survival of hips in the primary and revision subgroups and, therefore, the data are presented as overall results.

In addition to the revised cups, three additional cups were seen to be radiographically loose and will probably need to be revised in the near future. Compared with the rates seen in our previous study, the survival rates have been deteriorating. Progressive wear and related osteolysis was seen in these younger and active patients, and this radiographic finding necessitated revision. Six of the sixteen revised acetabular components were both intraoperatively and radiographically well fixed, and this supports the hypothesis that it would not be the reconstruction itself but the secondary problems that would cause a decline in survival. The survival of 77% after twenty-five years, with an end point of revision of the cup for aseptic loosening, is comparable with long-term reports on cemented hips in young patients, while we used this technique in demanding primary total hip arthroplasties and acetabular revisions.

Uncemented hip designs are mostly used currently in young patients, but reports on uncemented cups with bone-grafting in patients younger than fifty years old with a minimum follow-up of fifteen years are lacking. However, good results with uncemented cups in combination with acetabular grafts in hip revisions are reported by several authors in older patients. In hips undergoing revision, Rudelli et al. showed a survival rate of 88.3% in uncemented cups, with an end point of revision for any reason, after a mean follow-up of 167 months in a group of forty-two patients (forty-three hips) with a mean age at surgery of fifty-six years. Palm et al. reported a nine-year survival rate of the cup of 90.5% in a group of seventy-nine patients in whom the median age was sixty-seven years. Lachiewicz and Poon reported the results of thirty-four patients in whom morselized bone grafts were used in combination with a Harris-Galante porous-coated cup, and no revision because of loosening had taken place after a mean follow-up of seven years for the total
group of patients. Although these are good and promising mid-term results, longer follow-up is needed to prove the true clinical value of these cementless techniques in young patients.

Pelvic osteolysis, which is seen at a higher frequency around uncemented components, is still an unsolved problem in young patients. In a series by Della Valle et al.\textsuperscript{14}, very acceptable results were achieved with use of a porous-coated acetabular component, but osteolysis was observed in more than 30\% of patients who were younger than fifty years.

The technique of reconstruction, as reported in our study, has basically remained the same over the years, with only minor changes. In the first years, a metal mesh was placed on top of the impacted bone grafts just before cementation. After one decade, we realized that this mesh was not very functional, so metal mesh is now used only to reconstruct segmental defects. In addition, our rehabilitation program has been changed, with patients now mobilized earlier with earlier weight-bearing, depending on the size of the reconstruction.

NOTE: The authors thank Jan Hendriks for his excellent statistical support.
References


Update of the study in Chapter 4 with long-term follow-up of 25 years
The use of solid acetabular grafts in DDH-patients

High survivorship of cemented sockets with roof graft for severe acetabular dysplasia

Busch VJ
Clement ND
Mayer PF
Breusch SJ
Howie CR

Abstract

Background: Socket fixation in patients with acetabular dysplasia can be technically demanding but the use of structural grafts can help to reconstruct the original center of hip rotation. Because reported survival rates differ, construct survival seems to depend on the technique of graft preparation and fixation.

Questions/purposes: What is the survivorship of cemented sockets with acetabular roof graft in patients with severe acetabular dysplasia? Do clinical scores equal those of patients without acetabular grafting?

Methods: We retrospectively reviewed 62 patients (74 hips) who had undergone cemented THA with acetabular roof graft. Mean age at surgery was 45 years (range, 19–71 years). Revisions and radiographic failures were determined and clinical scores (Oxford, SF-12) were obtained and matched to a control group. Kaplan-Meier analysis was used to determine survivorship at a minimum followup of 5 years (mean, 10.4 years; range, 5–16 years).

Results: Survivorship for all-cause revision was 98% (95% CI, 92.5%–100.0%) at 10 years followup. Two hips were revised for aseptic acetabular loosening and one hip for polyethylene wear. All grafts incorporated and no additional radiographic loosenings were seen. Patients with grafting had higher Oxford scores compared with the control group but other scores were equal.

Conclusions: In contrast to reported series and the common use of uncemented cups in patients with developmental dysplasia of the hip, we found high survivorship of cemented sockets with roof graft in severe acetabular dysplasia at a mean followup of more than 10 years. These patients showed higher Oxford scores than patients in a control group. This technique that restores bone stock is a reasonable solution for often young patients with dysplasia.
Introduction

Restoration of the center of hip rotation in patients with developmental dysplasia of the hip (DDH) is advocated by most authors and this can be achieved in most patients using a standard hip implant without reconstruction of the deficient acetabulum. In more severe dysplastic cases, however, a deficient acetabulum may appear inadequate to support a standard implant. Several options are available to reconstruct the deficient acetabulum. The technique of impaction bone grafting was introduced by Slooff et al. and evaluation of this technique applied in young patients shows acceptable long-term survival rates of 77% at 25 years with revision for aseptic loosening as the end point. In a series of 84 patients younger than 40 years at the time of surgery, 10-year survival of acetabular reconstruction using impaction bone grafting was 95% with revision for aseptic loosening. In 28 acetabular reconstructions in 22 patients with primary diagnosis DDH, survivorship of 84% was reported at 15 years with revision for any reason as the end point. Impaction bone grafting of acetabular defects has developed as a proven technique with high long-term survival rates, but other options like the use of solid grafts are also available. Uncemented cups are the preferred technique today by most surgeons and several studies evaluated the survival of acetabular bulk grafting with uncemented THA. However, few studies are available with a mean followup of 10 years or longer. Hendrich and Mehling presented a series of patients with DDH (56 hips) with a survival rate of 91.6% at 11 years but substantial socket migration was observed in 19 hips. Kim and Kadowaki showed 94% survival at 10 years in a series of 83 hips. Shetty et al. reported in a series of 15 cases that no revisions were necessary at 10 years of followup but observed resorption of the graft in five of 15 cases. Solid grafts with a cemented socket are less widely used and some early reports showed increase of failure rates at longer followup. Mulroy and Harris reported a decline of survival in time with failure of 46% at 11.8 years. Shinar and Harris presented a total rate of loosened or revised cups of 60% after a followup of more than 16 years in a series of 81 cases of bulk grafts with cemented THA. Despite these discouraging results, long-term studies with a mean followup of 10 years or longer and high survival of bulk grafts and cemented THA have been reported. Kobayashi et al. presented a series of 37 reconstructions using bulk grafts and cemented THA.
without any reoperations at a mean followup of 19 years. Survival of acetabular bulk grafts seems to depend on the technique applied and younger age is related to lower survival of THA.²² ⁴²

To address the controversy in choice of treatment for patients with DDH, we therefore (1) determined the survival of roof grafts with a cemented THA; (2) evaluated survivorship of roof grafts in patients younger versus older than 50 years at the time of surgery; (3) determined radiographic failures and complications; and (4) compared the clinical scores of patients with roof grafting with those of a matched control group of patients with nondysplastic hips and, if possible, identify predictors of the scores.

Patients and Methods

We performed a retrospective, observational study by identifying all 62 patients (74 hips) with DDH from the prospective database at our institute who underwent a cemented THA in combination with an acetabular autogenous bulk roof graft from 1995 to 2006. During that time we performed more than 900 primary THAs each year. The indication for THA with a roof graft was painful secondary osteoarthritis of the hip with a deficient acetabular roof of 20% or more. The contraindication was acetabular roof deficiencies of less than 20%. We excluded all patients who had no acetabular augmentation or required acetabular reconstruction using additional impaction bone grafting. Twenty-four hips had previous hip surgery. The study group consisted of 57 female patients (67 hips) and five male patients (seven hips) with a mean age at surgery of 45 years (range, 19–71 years). Three patients were lost to followup, leaving 59 patients for study. Three patients (three hips) died 1, 6, and 12 years after surgery of causes unrelated to the surgery but their data were included in the survival analyses. The minimum followup was 5 years (mean, 10.4 years; range, 5–16 years). No patients were recalled specifically for this study; all data were obtained from medical records, radiographs, and questionnaires.

The study cohort was younger with a predominance when compared with the control group (Table 1). The control group, however, had a greater level of comorbidity (Table 1).
The use of solid acetabular grafts in DDH-patients

### Table 1:
Details and clinical scores of study group and control group

<table>
<thead>
<tr>
<th>Case-mix variables</th>
<th>Study group (n = 30)</th>
<th>Control group (n = 1312)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean years, SD)</td>
<td>45.6 (10.9)</td>
<td>69.2 (9.7)</td>
<td>&lt; 0.0001*</td>
</tr>
<tr>
<td>Sex (male/female)</td>
<td>1/29</td>
<td>553/759</td>
<td>&lt;0.0001†</td>
</tr>
<tr>
<td>Mean number comorbidities (SD)</td>
<td>0.8 (1.2)</td>
<td>1.9 (1.7)</td>
<td>0.002‡</td>
</tr>
</tbody>
</table>

### Preoperative (SD)

| SF-12 PCS | Not available | 31.1 (13.6) |
| SF-12 MCS | Not available | 50.8 (14.4) |
| OHS | Not available | 41.9 (8.2) |

### Outcome measures

| SF-12 PCS | 48.2 (10.5) | 44.8 (15.9) | 0.09* |
| SF-12 MCS | 52.5 (9.7) | 54.0 (13.8) | 0.39* |
| OHS | 16.9 (5.3) | 21.3 (9.2) | 0.009‡ |
| Satisfied (number, %) | 30 (100) | 1198 (91.3) | 0.10 |

**Abbreviations:** *t-test; †chi square; ‡Mann Whitney U-test; PCS = physical component score; MCS = mental component score; OHS = Oxford hip score.

Preoperative radiographic documentation was complete for 50 hips and was reviewed by two of the authors separately (VB, SJB). DDH was graded in a blinded fashion according to the Crowe classification\(^{10}\), the system of Hartofilakidis et al.\(^{22}\), and the Edinburgh classification\(^{19}\) (Table 2), which additionally identifies problems the surgeon might encounter during reconstruction (eg, retained hardware) and distinguishes concerns on the acetabular and femoral sides.

### Table 2:
Distribution of developmental dysplasia of the hip classifications according to Crowe, Hartofilakidis, and the Edinburgh classification systems

<table>
<thead>
<tr>
<th>Crowe</th>
<th>Percent</th>
<th>Hartofilakidis</th>
<th>Percent</th>
<th>Edinburgh system</th>
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<th>Percent</th>
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</tbody>
</table>
A posterolateral approach without trochanteric osteotomy was used in all cases. If, based on preoperative radiographs, the original center of hip rotation needed to be restored or in case of a deficient roof of more than 20% during surgery, an anterosuperior solid graft was used for reconstruction. A wedge of the femoral head was taken and fixed with two cancellous screws with its sclerotic concave side toward the defect as an inlay graft (Fig. 1). Further reaming of the inferior part of the graft was performed to create the optimal space for insertion of a standard cemented Contemporary or Exeter low-profile, all-polyethylene cup (Stryker, Newbury, UK) (Fig. 2). This technique creates a relatively small acetabular bulk autograft, which is supported by host bone. A femoral shortening osteotomy was necessary in 14 cases (Crowe III and IV) to facilitate restoration of the original center of hip rotation. An Exeter stem (Stryker) was inserted using modern cementing techniques. All patients received systemic prophylactic antibiotics (1.5 g cefuroxime) before surgery.

Fig. 1A–C
Schematic overview of graft insertion and reaming.

(A) Graft is fixated with two cancellous lag screws with its sclerotic concave side toward the defect as an inlay graft.

(B) Reaming of the graft to prepare for a cemented socket.

(C) Final situation before cementation and insertion of the acetabular component.
Postoperatively, all patients had chemical thromboembolism prophylaxis for 6 weeks or 3 months after surgery. Patients were mobilized routinely and were allowed 50% weightbearing for 6 weeks after surgery and then mobilized full weightbearing. Our standard postoperative protocol includes clinical and radiographic review at 6 weeks, 3 months, and 1 year after surgery. After the first year, review took place on a regular base or on indication decided by the consultant.

Postoperative radiographic documentation was complete of 49 surviving hips in living patients at followup times ranging from 2.5 to 15.3 years. One of us (VB) assessed structural quality and consolidation of the roof graft, interface radiolucencies and osteolysis, prosthesis migration, socket tilting, heterotopic ossification, and wear. Graft incorporation was defined as the manifestation of a regular radiodensity and trabecular bone structure throughout the graft and host bone with a continuous trabecular pattern according to Conn et al.\textsuperscript{9}. Radiolucent lines more than 2 mm wide were described and were defined as stable or progressive in time. Acetabular zones were identified using the criteria of DeLee and Charnley\textsuperscript{14} and radiographic failure was defined as radiolucent lines in all three zones and/or migration of 5 mm or more in any direction on the AP pelvic view relative to the interteardrop line. Linear wear was measured as described by Livermore et al.\textsuperscript{36}. Radiolucent zones on the femoral side were evaluated using the method of Gruen et al.\textsuperscript{20}. Loosening of the femoral component was defined using the criteria of Harris et al.\textsuperscript{21}. Definite loosening of the stem was defined as the appearance of a radiolucent line in all Gruen zones that

\begin{figure}
\centering
\includegraphics[width=\textwidth]{situation_after_cementation_of_the_acetabular_component_with_supporting_graft_and_restoration_of_original_center_of_hip_rotation}
\caption{Situation after cementation of the acetabular component with supporting graft and restoration of original center of hip rotation.}
\end{figure}
did not exist on the immediate postoperative radiographs, a crack in the cement, or fracture of the stem. Femoral prosthetic subsidence was considered abnormal if it was more than 2 mm\(^3\).

For the purpose of this study, patients were sent a questionnaire and were asked to complete the Oxford hip score\(^1\), the SF-12\(^2\), the EQ5-D\(^3\), and visual analog scale scores for pain\(^4\). The obtained information was combined with data available from the records. Complications were recorded according to the classification of Dindo et al.\(^5\). Kaplan-Meier survivorship analysis\(^6\) was performed for the entire study cohort and additionally for patients who were 50 years or younger at the time of surgery versus patients who were older than 50 years. End points used were revision of one or both components for any reason and revision for aseptic loosening. A radiographic worst case scenario was included, in which the assumption was made that the patients without a recent radiograph (16 hips) and the three patients (three hips) lost to followup had failed at least radiographically (total of 26%). Conventional worst case scenario survivorship was calculated comprising all known failures and those lost to clinical followup. Log-rank testing was used to compare survival rates of patients younger and older than 50 years.

The SF-12 and the Oxford hip scores for the study cohort were compared with a control group (Table 1). The control group consisted of patients undergoing a THA for primary osteoarthritis using conventional acetabular cementing techniques from a previously published study reporting the 1-year outcome according to the patient’s socioeconomic status\(^8\). The prior study also included bilateral THA; for the purposes of this study, only the first THA was included for comparative analysis. Parametric and nonparametric tests were used as appropriate to assess continuous variables for significant differences between groups. An unpaired Student’s t-test or a Mann-Whitney U-test was used to compare linear variables between groups. Dichotomous variables were assessed using a chi square test. All case-mix variables (age, sex, number of comorbidities, preoperative SF-12 mental component scores [MCS] and physical component scores [PCS], and the Oxford hip score) were entered into a multivariable linear regression model, using enter methodology, to assess the independent effect of the groups on outcome (SF-12 MCS and PCS and the Oxford hip score). All case-mix variables and postoperative SF-12 MCS and PCS and the Oxford hip score were entered into a multivariable binary logistic
regression model using enter methodology to assess the independent effect of the groups on satisfaction. We presumed an improvement greater than 3 points in the Oxford hip score would be clinically important. Statistical analysis was performed using Statistical Package for Social Sciences Version 17.0 (SPSS Inc, Chicago, IL, USA).

Results

All-cause survivorship was 98% (95% CI, 93%–100%) at 10 years (Fig. 3). Thirty-seven hips were still at risk at 10 years of followup and all patients with a minimal followup of 5 years were included in the study. The conventional worst case scenario, assuming that all patients lost to followup were revised, showed a 10-year survival rate of 93% (95% CI, 91%–96%). Radiographic worst case scenario analysis (assuming all patients with no radiographic followup as a radiographic failure) predicted a survivorship of 83% (95% CI, 69%–97%) at 10 years followup. Three hips had been revised, two hips for aseptic loosening of the cup at 7.9 and 17.4 years after the index operation. One hip was revised after 12.4 years because of wear and instability. No stem revisions were performed. At the time of subsequent

Fig. 3
A Kaplan-Meier curve showing survivorship with revision for all reasons as the end point.
revision, the grafts had integrated into the acetabular roof in all hips, as suggested by bleeding bone within the graft; the graft fixation screws were removed at the time of revision.

Separate analysis of patients 50 years old or younger demonstrated a survivorship rate of 93% at 10 years (Fig. 4), which was similar to ($p = 0.56$) the survival of patients older than 50 years.

Of the 47 surviving hips in living patients with complete radiographic followup, all grafts showed bony incorporation (Fig. 5A–C). Acetabular radiolucent lines were seen in 14 hips (30%), all in Zone 3. Osteoporosis was present in seven hips around the screws not adjacent to the acetabular component and was nonprogressive. Two hips showed osteolysis in Zone 1. None of the hips showed migration. The mean linear wear measured 0.07 mm per year (range, 0–0.27 mm). None of the femoral components migrated more than 2 mm. A progressive radiolucent line was seen in one hip in Gruen Zone 1; none of the femoral components had evidence of radiographic loosening. One femur had delayed union after shortening osteotomy but clinical symptoms were absent (Grade I according to Dindo et al). One patient sustained incomplete femoral nerve palsy but had a full recovery (Grade I).
The use of solid acetabular grafts in DDH-patients

Fig. 5A–C

(A) Preoperative radiograph of a 55-year-old woman with bilateral DDH, classified as a Crowe III, Hartofilakidis C, and Edinburgh system A2 F3.

(B) Postoperative radiograph showing bilateral reconstruction using roof grafts and a cemented Exeter THA after femoral shortening osteotomy.

(C) Radiograph 15 years after the reconstruction showing incorporation of the roof grafts without evidence of loosening or resorption of the graft but signs of wear.
Two patients were diagnosed with a pulmonary embolism and one patient with postoperative deep vein thrombosis (Grade II). All were treated successfully with warfarin. One patient had three dislocations 2 years after surgery and closed reduction was successful without damage to the acetabular reconstruction (Grade IIIb). Revision was not necessary.

Patients who had reconstruction using a roof graft had better \( p = 0.009 \) Oxford hip scores. SF-12 PCS and SF-12 MCS were similar \( p = 0.09 \) and \( p = 0.39 \), respectively. Adjusting for confounding case-mix variables, roof grafting was not an independent predictor of outcome, although there was a trend toward a better outcome and greater satisfaction in the study cohort (Table 3). The median postoperative EQ-5D score was 89.5 for the study group. The EQ-5D score was not available for the control group.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>B</th>
<th>95% CI</th>
<th>p value</th>
<th>R2</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF-12 PCS</td>
<td>-0.47</td>
<td>-4.2 to 3.3</td>
<td>0.81</td>
<td>0.15*</td>
</tr>
<tr>
<td>SF-12 MCS</td>
<td>-2.30</td>
<td>-9.1 to 4.5</td>
<td>0.51</td>
<td>0.10*</td>
</tr>
<tr>
<td>OHS</td>
<td>-1.3</td>
<td>-7.3 to 4.7</td>
<td>0.67</td>
<td>0.04*</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>0.00005</td>
<td>-</td>
<td>0.99</td>
<td>0.38†</td>
</tr>
</tbody>
</table>

*Abbreviations: * Linear regression analysis; †binary logistic regression analysis; PCS = physical component score; MCS = mental component score; OHS = Oxford hip score.

**Discussion**

Structural grafts have been used in patients with more severe dysplasia to reconstruct the original center of hip rotation. However, the reported survival rates differ considerably. We presume construct survival depends in part on the techniques used for graft preparation and fixation. To address the conflicting survival rates, we (1) determined the survival of roof grafts with a cemented THA; (2) evaluated survivorship of roof grafts in patients younger versus older than 50 years at the time of surgery; (3) determined radiographic failures and complications; and (4) compared the clinical scores of patients with roof grafts with those of a matched control group of patients with nondysplastic hips and if possible identified predictors of the scores.
Our study was associated with a number of limitations. First, 19 of the 74 hips did not have radiographs at final review. However, they were included in a worst case scenario analysis with a potential radiographic failure rate of 17% at a mean follow-up of 10 years. Second, only one of us observed the postoperative radiographs at final review so we cannot provide any data on interobserver variability. Definite radiographic loosening however is expected to cause problems in young patients and the radiographic data do not jeopardize the presented data on revisions and survival rates. Third, we have not measured the level of activity of our patients, which might have influenced the survivorship and clinical scores. Because survivorship of THA seems to be related to activity of patients by means of accelerated wear and osteolysis, it would be worthwhile including an activity score in our questionnaire in the future. Fourth, the present study has a retrospective design with a limited number of patients. However, this is the best evidence available at the moment and we have included all patients available with a minimal followup of 5 years or longer at our institute.

All-cause survivorship was 98% at 10 years followup, which is comparable to other reported series on patients with DDH that show high survival of bulk acetabular grafts with a mean followup of 10 or more years (Table 4). Although high failure rates have been reported using bulk grafts with cemented THA, we would like to confirm previous studies that high survival rates can be obtained using solid grafts with cemented THA. Comparison of grafting (32 cases) versus nongrafting (48 cases) of severe acetabular defects in a series of 64 patients showed higher survival rates of grafted cases. Solid grafts to reconstruct acetabular defects of more than 20% is the philosophy at our institute. Bulk grafts in combination with uncemented THA remain controversial. Several early reports show high survival rates but series with longer followup are scarce. Shetty et al. reported in a series of 15 cases that no revisions were necessary at 10 years of followup but observed resorption of the graft in five of 15 cases, a finding that was not present in our series.

Survival of THA in young patients is lower than survival of THA in older patients, presumably because of their higher demands on their prosthesis, although we acknowledge the fact that age by itself should be interpreted cautiously in young patients because activity levels may differ between patients, also in time. Unfortunately, we have not assessed activity in the present study so we made
subgroups of patients younger and older than 50 years old at the time of surgery. We could not detect a difference in survival between these two groups, possibly because of the small number of revisions in the present series. Longer followup is needed to confirm this hypothesis.

### Table 4:
Overview of literature† of acetabular bulk grafts in patients with DDH with a mean follow-up of 10 years or longer

<table>
<thead>
<tr>
<th>Author</th>
<th>Number of hips</th>
<th>Number of patients</th>
<th>Mean age in years (range)</th>
<th>Type of fixation</th>
<th>Mean followup in years (range)</th>
<th>Survivorship revision for aseptic loosening/radiographic loosening</th>
</tr>
</thead>
<tbody>
<tr>
<td>Akiyama et al. [1]</td>
<td>147</td>
<td>119</td>
<td>56 (38–76)</td>
<td>Cemented</td>
<td>11.8 (6–15)</td>
<td>96%/91% at 15 years</td>
</tr>
<tr>
<td>Bobak et al. [4]</td>
<td>45</td>
<td>41</td>
<td>46 (25–73)</td>
<td>Cemented</td>
<td>11 (10–15)</td>
<td>100%/88% at 11 years</td>
</tr>
<tr>
<td>Hendrich and Mehlng [23]</td>
<td>56</td>
<td>47</td>
<td>50.4</td>
<td>Uncemented</td>
<td>10.2</td>
<td>91.6%/88.9% at 11 years</td>
</tr>
<tr>
<td>Iida et al. [27]</td>
<td>133</td>
<td>112</td>
<td>53 (33–72)</td>
<td>Cemented</td>
<td>12.3 (8–24)</td>
<td>96%/83% at 15 years</td>
</tr>
<tr>
<td>Inao and Matsuno [28]</td>
<td>20</td>
<td>18</td>
<td>48 (20–66)</td>
<td>Cemented</td>
<td>12.9 (10–18)</td>
<td>100%/85% at 12.9 years</td>
</tr>
<tr>
<td>De Jong et al.[12]</td>
<td>116</td>
<td>102</td>
<td>64.4 (35–84)</td>
<td>Cemented</td>
<td>17.6 (11–26)</td>
<td>85%/82% at 15 years*</td>
</tr>
<tr>
<td>Lee et al. [34]‡</td>
<td>102</td>
<td>95</td>
<td>51 (21–78)</td>
<td>Cemented</td>
<td>10.2 (4–18)</td>
<td>65%/62% at 12 years</td>
</tr>
<tr>
<td>Kim and Kadowaki [31]</td>
<td>83</td>
<td>70</td>
<td>57 (33–72)</td>
<td>Uncemented</td>
<td>11 (9–14)</td>
<td>94%/97% at 10 years*</td>
</tr>
<tr>
<td>Kobayashi et al. [39]</td>
<td>37</td>
<td>30</td>
<td>57 (48–73)</td>
<td>Cemented</td>
<td>19 (10–26)</td>
<td>100%/100% at 19 years</td>
</tr>
<tr>
<td>Mulroy and Harris [39]</td>
<td>46</td>
<td>37</td>
<td>46.5 (14–69)</td>
<td>Cemented</td>
<td>11.8 (10–16)</td>
<td>80%/54% at 11.8 years</td>
</tr>
<tr>
<td>Rodriguez et al. [41]</td>
<td>29</td>
<td>23</td>
<td>49 (20–78)</td>
<td>Cemented</td>
<td>11 (7–17)</td>
<td>80% at 15 years/60% at 15 years</td>
</tr>
<tr>
<td>Shetty et al. [44]</td>
<td>15</td>
<td>15</td>
<td>59 (20–85)</td>
<td>Uncemented</td>
<td>10 (8–11)</td>
<td>100%/100% at 10 years</td>
</tr>
<tr>
<td>Shinar and Harris [45]</td>
<td>81</td>
<td>73</td>
<td>45.2 (16–69)</td>
<td>Cemented</td>
<td>16.5 (14–21)</td>
<td>65%/40% at 16.5 years*</td>
</tr>
<tr>
<td>Stringa et al. [51]</td>
<td>21</td>
<td>19</td>
<td>51 (22–68)</td>
<td>Cemented</td>
<td>10 (5–14)</td>
<td>100%/85% at 10 years</td>
</tr>
<tr>
<td>Current study</td>
<td>74</td>
<td>48</td>
<td>45 (19–71)</td>
<td>Cemented</td>
<td>10.3 (5–16)</td>
<td>98%/98% at 10 years</td>
</tr>
</tbody>
</table>

Abbreviations: *Survivorship with revision for any reason as the end point; †series of patients with different diagnosis; 57% had DDH; survival shown of primary THA in patients with DDH patients; ‡literature reported until September 2011; DDH = developmental dysplasia of the hip.
Radiographic results of the present series compare favorably with reported series (Table 4) and we have included a worst case scenario showing 83% survival at 10 years assuming that all hips without a recent radiograph had failed. We did not observe extensive acetabular osteolysis with cemented socket fixation, which is a well-reported observation around uncemented cups6, 15. The use of an all-polyethylene cup enables the use of thicker polyethylene in these patients who all have small acetabula; this may further reduce the incidence of polyethylene wear. Wear-induced osteolysis increases the risk of failure and compromises bone stock for future revision surgery.

The improvement in patient-reported scores in the study group of patients with dysplastic hips and roof graft reconstruction compares favorably with our control group of patients with primary cemented THA with a difference in Oxford scores. An explanation might be that the amount of improvement is higher in reconstructed patients. Unfortunately, preoperative scores are not available because of the retrospective design of this study.

The treatment protocol at the Royal Infirmary in Edinburgh for dysplastic hips consists of reconstruction of a deficient acetabular roof of more than 20% using a solid graft from the femoral head with a cemented THA. Our data suggest this is a biologically reasonable approach, resulting in restoration of bone stock in these relatively young patients. Although some authors recommend avoiding structural bone graft if possible29, bulk grafts for reconstruction of acetabular defects provide additional value for future revisions3. The technique was originally described by Wolfgang 53, has been further described by Iida et al.27, and has been performed in the same way throughout this study. In the early years, three cancellous screws were used for fixation but we believe two screws are sufficient. A femoral shortening osteotomy was necessary to restore the center of hip rotation in almost 20% of cases. Except for one delayed union of the femoral osteotomy in a patient without symptoms in the present series, the results of femoral osteotomy are good as reported previously25. We recommend the use of roof grafts with cemented THA in patients with DDH.

Acknowledgments

We thank Deborah MacDonald and Paul Jenkins for their support.
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graft in patients who had congenital dislocation or dysplasia. A follow-up note.

arthroplasty with an autograft of the femoral head for developmental dysplasia of the


term results of cementless anatomic total hip replacement in dysplastic hips.

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The use of solid acetabular grafts in DDH-patients
Chapter 7

Uncemented total hip arthroplasty in patients under 50 years

Long-term outcome of 73 Zweymüller total hip prostheses with a screw cup in patients under 50 years of age

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Pouw MH
Laumen AM
van Susante JL
Vervest AM

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Abstract

Background: Total hip arthroplasty in young patients is associated with high failure rates and the best option for this demanding group of patients remains controversial.

Questions/purposes: What are the clinical and radiographic results of the uncemented Zweymüller total hip prosthesis in patients younger than 50 years?

Methods: We report the long-term results of 73 consecutive with a titanium threaded cup and a polyethylene insert in 67 patients younger than 50 years at the time of surgery (mean 43 years, range 23 - 49). Unbiased researchers followed patients clinically and radiographically and Kaplan-meier analysis was used to determine survival for different endpoints.

Results: Three hips were revised for septic loosening, three cups for aseptic loosening and one hip because of a periprosthetic fracture. Three patients (3 hips) died and eight patients (9 hips) were lost to radiographic follow-up without any reoperation. The mean follow-up was 17.5 (15 - 21) years and the mean HHS was 90 (52 – 100). Survival with endpoint revision for any reason was 89% (95% C.I. 85 - 93) and with revision for aseptic loosening 94% (C.I. 95 – 99) at 17 years, respectively.

Conclusions: Zweymüller total hip arthroplasty with a titanium threaded cup and a polyethylene insert showed good long-term results, even in this group of young patients.
Introduction

Total hip arthroplasty (THA) has become a successful procedure in orthopaedic surgery, especially in older patients. Treating end-stage osteoarthritis of the hip in young patients remains a challenge because a more active life-style and high demands on the prosthesis result in worse outcomes, particularly due to acetabular component failure\(^1\). The evidence for the use of uncemented implants in young patients remains a matter of debate\(^2\). Good midterm and long-term results using the Zweymüller Alloclassic total hip arthroplasty\(^3\)\(^\text{-}^8\) have been reported, but long-term outcomes in young patients are scarce\(^9\). The aim of our study was to evaluate the clinical and radiological results of the Alloclassic Zweymüller stem in combination with the conical self-tapping cement-free (CSF) titanium threaded cup and polyethylene insert and a ceramic head in patients younger than 50 years of age, with a follow-up of at least 15 years. Patients were reviewed in five hospitals in the Netherlands.

Patients, implants and methods

IRB/Ethics committee decided approval was not required for this study. Between January 1987 and December 1994, 67 patients aged under 50 years at the time of operation received 73 Zweymüller stems in combination with the CSF cup and a polyethylene insert. The mean age of the patients was 43 (23 – 49) years at surgery, and the group comprised 41 men and 26 women. Indications varied from primary osteoarthritis to osteonecrosis of the femoral head (Table 1). A posterolateral approach was used in all patients without a trochanteric osteotomy. Thirty-three Hochgezogen and 40 Stepless stems were inserted, all with the CSF cup with a polyethylene insert and a 32 mm ceramic head. Three patients (3 hips) died during follow-up. Seven patients (8 hips) refused to return to the hospital for clinical review, but their prosthesis was ‘in situ’ at the time of review so their data were used for survivorship analysis. Patients were clinically evaluated using the Harris Hip Score and a validated Dutch translation of the Oxford Hip Score\(^10\). Radiographs taken at the latest follow-up were analysed for signs of loosening, wear, osteolysis and heterotopic ossification. Loosening of the cup was defined as change
of cup angle of > 3 degrees, migration of > 5 mm\textsuperscript{11} or a complete radiolucent line in 3 zones as defined by Delee and Charnley\textsuperscript{12}. Femoral implant stability was classified as described by Engh et al\textsuperscript{13}. Linear polyethylene wear was measured according to Livermore et al\textsuperscript{14} and osteolysis was defined as a lytic lesion of more than 5 mm that was not observed on the direct postoperative radiographs. Heterotopic bone formation was graded using the criteria of Brooker et al\textsuperscript{15}. Survivorship analysis was calculated for different end-points using the Kaplan-Meier technique, including a worst-case scenario for survival of the cup.

Table 1: Preoperative diagnosis

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Number of hips (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idiopathic osteoarthritis</td>
<td>45 (62%)</td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
<td>11 (15%)</td>
</tr>
<tr>
<td>Ankylosing spondylitis</td>
<td>2 (3%)</td>
</tr>
<tr>
<td>Avascular femoral head necrosis</td>
<td>9 (12%)</td>
</tr>
<tr>
<td>Posttraumatic osteoarthritis</td>
<td>6 (8%)</td>
</tr>
</tbody>
</table>

**Results**

**Revisions and clinical results**

Seven hips were revised after a mean of 7.1 (2-17) years. Three hips were revised (at 2.0, 2.3 and 5.5 years) because of septic loosening, all by two-stage procedures. Three hips were revised (at 6.8, 7.0 and 17.1 years) because of aseptic loosening of the cup and one stem revision was performed because of a traumatic periprosthetic femoral fracture at 9 years. Of the 55 unrevised hips in living patients available for clinical review, the mean Harris Hip Score was 91 (52 – 100) at a mean follow-up of 17.5 years. The mean Oxford Score was 22 (14 – 43). One patient had a HHS of 52 and an Oxford Score of 43, mainly because of pain but an obvious cause could not be identified.

**Complications**

Besides the revised hips, three hips required re-intervention. Excessive heterotopic bone formation (Brooker grade IV) was removed in one hip. One
femoral component was revised three days after the index operation because of leg length discrepancy and one patient fractured the acetabulum 14 days after the operation for which revision of the cup was necessary. In view of the short period after the index-operation and unrelated causes to the prosthesis, these events were classified as re-interventions and not as failures of the prosthesis. Five hips (6.8%) dislocated within 10 weeks of operation and all underwent closed reduction without any symptoms in the long term.

**Radiographic analysis**

Of the 66 unrevised hips, follow-up radiographs were complete for 55 hips at final review (Fig. 1). Three cups of the unrevised hips were considered loose but no additional radiographic failures of the stem were seen. The mean linear wear of the unrevised hips in living patients measured 1.2 (SD 0.9) mm after an average follow-up of 17.5 (SD 5.9) years. Osteolysis was seen at acetabular zone 2 and 3 in three cases. Of the hips without any re-operation, heterotopic ossification was seen in 31 cases, grade 1 in 14 hips, grade II in 7 hips, and grade III in 10 hips. In 24 hips no heterotopic ossification occurred.
Survivorship analysis

Cumulative survival with endpoint revision of any of the components for any reason was 89% (C.I. 85-93%) (Fig. 2) and for aseptic loosening survival was 94% (C.I. 95-99%) at 17 years. With revision of the stem for any reason as the endpoint, survival was 94% (CI 92-96%) and for the cup survival was 90% (CI 92-98%) at 17 years. In a worst-case scenario for the cup where radiological failures were included and patients without a recent radiograph were considered failures, survival was 84% (CI 81-87%) at 17 years.

Discussion

Total hip arthroplasty in young patients remains a challenge, and the preferred implant in these active patients is a source of debate. Meta-analysis of cemented and uncemented implants in this context is inconclusive. Both cemented and uncemented stems perform well in young patients with survival rates of more than 90% at 10 years but higher failures rates are seen on the acetabular side. Eskelinen et al. found that in patients younger than 55 years of age survival rates of uncemented cups were unsatisfactory when liner exchanges were taken into account. Modern hip designs were evaluated and only the Harris Galante II cup
showed a 10-year survival rate of more than 80% at 10 years with revision of the
cup for any reason as an end-point. A recent report by the Swedish Hip Registry
demonstrated that after stratification into age groups, the long-term component
survival with revision for any reason was lower after uncemented THA in all but
the oldest age group\textsuperscript{18}. A separate analysis of the cup revealed that uncemented
cups had a significantly higher risk of cup revision due to aseptic loosening than
cemented cups. This difference even persisted after exclusion of revisions where only
liner exchange had been performed. In conclusion, a durable fixation of the cup
and wear-related problems are the primarily issues to be improved in uncemented
total hip arthroplasty, especially in young patients. In our study, the CSF cup also
performed worse compared to the stem but survival of the cup with endpoint
revision for any reason was still 90% at 17 years. This compares favourably to other
reported survival rates of uncemented cups in young patients. Reigstad et al.\textsuperscript{9} showed
a survival rate of 89% of the Endler titanium-backed screw cup (all revisions) at 18
years but a drawback could be that the liner in this cup is not exchangeable in case
of polyethylene wear. Aldinger et al.\textsuperscript{19} showed high survival rates of a gritblasted
femoral component but low survival rates (38% and 68% at 17 years) of two types
of smooth-surface threaded cups which they now no longer use. Therefore, porous-
coating of a threaded cup and bony in-growth are essential to achieve stability and
higher survival rates at longer follow-up. The design of the Zweymüller rectangular
stem and the conical threaded cup fulfil these criteria and provide primary stability
to facilitate bony in-growth\textsuperscript{20}. The main limitation of our study is its retrospective,
unblinded design and the number of patients who could not return for follow-
up. However, we have included a worst-case scenario. The Zweymüller total hip
arthroplasty with the CSF cup showed good clinical and radiological results with
high survival rates compared to other reported series, even in this group of patients
younger than 50 years of age.
References


Chapter 8

**Literature overview of total hip arthroplasty in young patients**

Total hip arthroplasties in young patients under 50 years: limited evidence for current trends. A descriptive literature review

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Schreurs BW

*Hip International 2011, Sep-Oct; 21(5):518-25*
Abstract

Background: Many types of THAs exist to treat young patients with degenerative hip disease. Currently, uncemented hip designs are mostly used in young patients in the Netherlands.

Questions/purposes: Are the hip implant-choice for young patients in The Netherlands evidence-based?

Methods: We examined all reported outcomes of uncemented and cemented total hip arthroplasties in patients younger than 50 years of age listed in Medline (1966-1 January 2009) and PubMed, and scrutinised reference lists of relevant papers. In addition, we evaluated relevant data in the Swedish Hip Arthroplasty register.

Results: 109 relevant articles were identified, 37 of which had a mean follow-up longer than 10 years. Although uncemented hip implants are widely used in patients under 50 years of age, there are only 2 reports that fulfil the criteria published by the National Institute for Clinical Excellence (NICE) in the United Kingdom (follow-up of >10yrs and survival of ≥90%).

Conclusions: Current trends relating to implant selection remain unsupported by survival data, and additional information about the long-term results of newer implants is essential. As matters stands, the most reliable results relate to cemented implants.
Introduction

Total hip arthroplasty (THA) is one of the most successful and cost effective interventions of modern medicine\(^1,2\). The era of cemented total hip arthroplasty was initiated by Sir John Charnley (1961), but it soon became apparent that the outcome of the procedure in younger patients was less favorable\(^3\)\(^-\)\(^5\). As a result, uncemented hip implants were developed for these patients, based on anticipated osseointegration of bone into a rough or coated outer surface (sometimes covered with hydroxyapatite). Such implants have been available for more than 25 years. In many countries uncemented total hip implants dominate the market and are frequently used in younger patients. In some countries, cemented implants are hardly ever used in patients under 50 years of age. Over 90% of all THAs inserted in North America are uncemented, while >90% of all THAs implanted in Scandinavia and some countries in Europe are cemented, creating the so-called ‘north Atlantic divide’. The objective of THA in young patients is long-term implant survivorship\(^6\). Most short-term and intermediate-term studies are not helpful in differentiating failing components from successful ones\(^6\). The discussion relating to uncemented and cemented total hip arthroplasties in young patients has continued\(^7\)\(^,\)\(^8\), prompting us to perform a literature review of all available studies about THA in patients under the age of 50. Long-term outcome of THA is generally defined as the outcome 10 years or more after surgery. For this review we adopted the recommendations of the NICE 2003 report of a survival rate of 90 percent or more of the whole implant at 10 years\(^9\). We studied the literature relating to THA in patients under the age of 50 which allowed examination using these criteria. We also performed a statistical analysis of the results of uncemented and cemented outcomes in studies with a mean follow-up longer than 10 years on average.

Methods

A systemic literature review was performed searching Medline and PubMed (1966 - 1 January 2009) for articles related THA in patients less than 50 years. Two groups of key words were used in combination with each other (group 1: less, 50, fifty, 45, 40, forty, 35, 30, thirty, 25, 20, twenty, or young* and group 2: arthroplast*,
hip, acetabul*, femor*, component*, cement*, uncement*, or noncement*). Asterisks were used to expand the search field of a key word. We also searched the reference list of selected papers for relevant additional studies. Inclusion criteria were as follows: primary total hip arthroplasty, age at index surgery <50, and minimum mean follow-up of 10 years. An additional inclusion criterion was used incorporating the NICE criteria of survival of ≥90% with an endpoint of revision for any reason of either component for the descriptive review. We also included combinations of fixation techniques (multiple techniques). In ‘hybrid’ THA uncemented cups are combined with cemented stems, and in ‘reverse hybrid’ THA cemented cups are combined with uncemented stems. Exclusion criteria were studies with only bipolar or resurfacing arthroplasty, THA for tumours, reports of only one component, and studies with incomplete data (for example studies only reporting aseptic survival). Revision was defined as the removal or replacement of one or more components of the arthroplasty. Liner exchanges in uncemented implants were also considered as a revision. The retrieved articles were first scanned for relevance and subject. The resulting articles were evaluated in relation to the number of patients and THAs, age of the population (mean and range), duration of follow-up, type of implant(s) used, surgical techniques used (cemented, uncemented, hybrid or multiple techniques) and survival outcome. When survival was only depicted graphically, the 10 year survival was estimated from the graph. Authors of articles with acceptable long-term results (>10 yrs) were contacted if the results at 10 years were not reported or no survival graph was present, to obtain the 10 years results of these studies. The articles were reviewed by two independent reviewers and both extracted data from the articles. For statistical analysis, update studies of previous reports were excluded from the statistical analysis in order to prevent inclusion of the same results more than once, and only studies with an endpoint of revision for any reason were included. A scatter plot was used to outline any publication bias and we used a weighted regression analysis for testing significant differences in survival between the different fixation types, correcting for (if reported) population size, 95% confidence intervals, and number of patients remaining after 10 years.
Results

Papers

The search query resulted in 2999 ‘hits’ and after evaluation and selection 109 studies reported THA survival in patients under the age of 50. Of these 109 studies, 37 studies had a mean survival of >10 years, and 15 articles complied with the criteria of a reported survival of ≥90% after a mean follow-up of >10 years. Figure 1 summarises the articles included in the search. Table 1 summarises details of articles on THA in patients under the age of 50, with a minimum average follow-up of 10 years, and with a survival of ≥90% with endpoint revision for any reason of either component. Of the 15 remaining studies, 1 was about uncemented implants, 13 were about cemented THA and 1 reported the use of multiple techniques (uncemented and hybrid implant fixation). No prospective comparable studies were available which fulfilled the search criteria.
<table>
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<tr>
<th>Study</th>
<th>Ref.</th>
<th>No. Hips</th>
<th>No. Patients</th>
<th>Mean age (range)</th>
<th>Follow-up (range)</th>
<th>Type of Implant</th>
<th>Survival THP endpoint any reason (95% C.I.)</th>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>10</td>
<td>42</td>
<td>25</td>
<td>21 (11-35)</td>
<td>11.2 (8-13)</td>
<td>HA CAD-CAM</td>
<td>90% (78-97%)</td>
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<td>Cemented</td>
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<td></td>
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<td>11</td>
<td>46</td>
<td>34</td>
<td>38 (24-49)</td>
<td>12 (10-18)</td>
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<td>69</td>
<td>42 (18-49)</td>
<td>20 (5-25)</td>
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<td>12</td>
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<td>46</td>
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<td>13 (0.3-21)</td>
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<td>13</td>
<td>218</td>
<td>141</td>
<td>32 (16-40)</td>
<td>16 (10-24)</td>
<td>Charnley</td>
<td>93% (SE 1.8)</td>
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<td>14</td>
<td>93</td>
<td>69</td>
<td>42 (18-49)</td>
<td>25.8 (25- n/a)*</td>
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<td>17</td>
<td>287</td>
<td>222</td>
<td>40.1 (15-50)</td>
<td>14.5 (0.5-25)</td>
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<td>95.9% (92.8-98.4%)</td>
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<td>18</td>
<td>66</td>
<td>n/a</td>
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<td>14 (10-20)†</td>
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<td>19</td>
<td>123</td>
<td>101</td>
<td>42 (n/a-50)</td>
<td>12.5 (10-17)</td>
<td>Exeter</td>
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<td>161</td>
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<td>19.7 (2-30)</td>
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<td>24</td>
<td>28 (19-39)</td>
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<td>16</td>
<td>89</td>
<td>67</td>
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<td>18 (16-22)</td>
<td>Charnley</td>
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<td>173</td>
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</tr>
<tr>
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<td>23</td>
<td>292</td>
<td>195</td>
<td>38 (12-50)</td>
<td>15 (1-36)</td>
<td>Charnley</td>
<td>93% (90-96%)</td>
</tr>
<tr>
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<tr>
<td>Singh et al (2004)</td>
<td>24</td>
<td>38</td>
<td>33</td>
<td>42 (22-49)</td>
<td>10 (5.3-14.2)</td>
<td>HA JRI Furlong</td>
<td>Hybrid: 100% (78-100%)</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td>Uncemented: 96% (75-100%)</td>
</tr>
</tbody>
</table>

**Abbreviations:** *: Updates of same cohort; †: deceased excluded. HA: Hydroxyapatite-coated.
Uncemented total hip implants

Only one study about uncemented implants fulfilled the NICE criteria, the study by McCullough et al.\textsuperscript{10}, in which a survival of 90\% at 10 years was reported, following the use of a custom-made hydroxyapatite-coated femoral implant. They studied 42 hips in 25 patients with inflammatory polyarthritis. The mean age in this study was 21 (11-35) years. Patients aged less than 16 years had the highest risk of failure of the femoral component (28.5\% at 10 years). However, in normal standard orthopaedic practise it is very unusual to implant custom made prostheses.

Cemented total hip implants

Boeree and Bannister\textsuperscript{11} reported the outcome of 46 cemented THAs in 34 patients under 50 years. The average age was 38 (24-49) years. Most had rheumatoid arthritis (12 hips) or congenital hip dysplasia (11 hips). The survival rate was 90\% at 10 years, marginally meeting the NICE criterion. Emery et al.\textsuperscript{12} reported on 57 THAs in 46 patients under the age of 50 years. The average age was 41 (17 to 49) years and the average follow-up was 13 years. Most frequent diagnoses were primary osteoarthritis (23 hips), rheumatoid arthritis (12 hips) and congenital hip dysplasia (10 hips). The survival of the implant was 90\% at 10 years. After 10 years there was a large decline in survival with a survival of 68\% at 15 years. Joshi et al.\textsuperscript{13} reported on the long-term outcome of 218 cemented THAs in 141 patients under 40 years (mean 32, range 16-40 years). Indications were rheumatoid arthritis (74 hips), congenital hip dysplasia (47 hips), ankylosing spondylitis (41 hips) and osteoarthritis (56 hips). The survival of the implant with an endpoint being revision of any part of the prostheses was 93\% at 10 years and 75\% at 20 years. Keener et al.\textsuperscript{14} reported the 25 years results after 93 cemented THAs in 69 patients under 50. The average age was 42 (18-49) years. Diagnoses varied, but most had congenital hip dysplasia (28 hips), primary osteoarthritis (11 hips) and posttraumatic arthropathy (11 hips). However, the survival rate at 10 years was not reported, but the reported survival curves indicate that the 10 year survival fulfils the 90\% criterion. The survival rate with an endpoint of revision for any reason was reported as 69\% at 25 years and 60\% at 30 years. The evaluated cohort in the study of Keener et al was an update of the same cohort first reported by Callaghan et al.\textsuperscript{15} and Sullivan et al.\textsuperscript{16}, all showing the same results after 10 years. Kerboull et al. reported the results of 287 Charnley-Kerboull implants\textsuperscript{17}. The 222 patients had a mean age of 40 (15-50) years and were
followed up for up to 25 years. There was no significant differences in implant survival in patients under and above the age of 40. The only predictive factor for loosening was a wear rate higher than 0.1 mm per year. Kobayashi et al.\textsuperscript{18} reported the outcome of 66 cemented THAs in patients under 50 years. The average age was 37 (18-50) years. Most frequent diagnoses were rheumatoid arthritis (18 hips) and osteoarthritis. At 10 years cup survival was 98%. Stem survival was not reported at 10 years but at 16 years was 96%. Even if cup and stems revisions were performed separately, (and including one revision for septic loosening excluded by the authors), the 90% survival at 10 years criterion was fulfilled. Revisions rates were highest in the patients with rheumatoid arthritis. Lewthwaite et al.\textsuperscript{19} reported the results of the cemented Exeter THA in patients under the age of 50. They observed implant survival of 94.4% after 10 years, after evaluation of 123 hips in 101 patients. A significant proportion (44 patients) of their original population was excluded from analysis. By 10 years, 6 hips had been revised and 1 periprosthetic fracture occurred but the original components retained. Sochart and Porter\textsuperscript{20} reported the long-term results of 43 THAs in 24 young patients (mean age 28 years) who had ankylosing spondylitis, 18 to 30 years after surgery. Implant survivorship was 91% at 10 years, 73% at 20 years and 70% at 30 years. A further report by Sochart and Porter observed the long-term results of 226 cemented THAs in 161 patients in patients under 40\textsuperscript{21}. The average age was 32 (17-39) years. Indications were congenital dislocation of the hip (60 hips), primary osteoarthritis (66 hips) and rheumatoid arthritis (100 hips). Implant survivorship was 91% at 10 years, 67% at 20 years and 65% at 25 years. Primary osteoarthritis was associated with the worst results (86% survival at 10 years). Wroblewski, Siney and Fleming provided two reports, probably based on one population under 50, with survivorship fulfilling the NICE criteria. A subgroup of 190 hips in 173 patients with low-wear rates achieved implant survival of 95% at 10 years\textsuperscript{22}. The second paper reported 292 hips in 195 patients with inflammatory arthritis and survival of 93% after 10 years\textsuperscript{23}. They concluded that wear and aseptic cup loosening were the main long-term problems.

**Hybrid total hip implants**

There were no studies available of ‘hybrid’ implanting techniques which fulfilled our study criteria.
Multiple implantation techniques
Singh et al.\textsuperscript{24} reported excellent implant survival in 38 hips in 33 patients. All patients had an uncemented JRI Furlong hydroxyapatite coated stem, the first 14 hips received a cemented cup and the remaining 24 a screw-fit hydroxyapatite coated cup. The mean age was 42 (22-49) years with an average follow-up of 10 (5.3-14.2) years. The reversed hybrid arthroplasties showed implant survival of 100% at 10 years and uncemented arthroplasties 96% at 10 years.

Scandinavian Hip Registers
The last available annual report of the Swedish National Hip Arthroplasty Register is from 2007\textsuperscript{25}, including survival of the cohorts of all cemented and uncemented THAs inserted in patients younger than 50 years in Sweden in the period 1992-2007. At 10 years, both cemented and uncemented implants demonstrated survivorship under 90%. At 16 years implant survival of cemented THAs in males was 74.7% (95%C.I. 67.4-82.1) and 72.5% (95%C.I. 66.4-78.7) in females. At the same time point (16 years) implant survival of uncemented THAs was 57.4% (95%C.I. 47.5-67.4) in males and 54.3% (95%C.I. 46.8-61.7) in females. Unfortunately, no detailed reports on individual implants were available to allow assessment of newer uncemented implants.

Statistical analysis
For statistical analysis, a scatter plot of all studies with a follow-up longer than 10 years with any survival rate was created (n=37) (Fig. 2). The log of the number of patients included in the studies was related to the overall outcome (survival) of the THA with an endpoint of revision for any reason of either component. 37 studies were included and the different fixation types were noted separately. No specific outliers were observed and therefore no publication bias was observed. Articles which were updates of previous work were not included in this statistical analysis (2 studies of cemented implants), and 1 study about cemented implants did not report survival with the endpoint of revision for any reason and was excluded. Singh et al.\textsuperscript{24} reported in their study covering multiple techniques the results of uncemented implants separately and therefore these results could be included. Ultimately, 23 studies covering 3759 patients with cemented THA (26 studies minus 2 updates and 1 incomplete report), and 7 studies of uncemented implants covering 372 patients
were included (6 studies plus the results of the uncemented implants of Singh et al.). A weighted regression analysis showed significantly better survival of cemented THA compared to uncemented THA: 87.7% (95%CI: 83.2-92.2%) versus 75.2% (95%CI: 66.3-84.1%) (difference: 13.7% (95%CI:9.7-17.7%); p< 0.001).

Discussion

Although uncemented implants are frequently selected for patients under 50 years of age (in some countries are exclusively used in these patients), there is limited clinical evidence that these implants really have improved the outcome for these patients at 10 years or more after surgery, based on the results reported. A confusing factor in assessing studies of uncemented hips is the fact that revision of a failed insert of an uncemented acetabular metal shell is not always reported as a revision. Not all studies report this exchange as a revision, which can make a dramatic difference in the reported outcome. Cup survival with an endpoint of revision of the metal shell at 14 years is 70%, but including liner exchange it is 54% (Capello et al.26). We believe that liner exchanges should be considered revisions. Further confusion is created
by the fact that many studies report only cup or only stem survival. In practice, patients will benefit only if both components survive. A confounding factor in our conclusions and statistical analysis could be that the underlying diagnoses of the hip disease and the activity levels of patients are not comparable between cemented and uncemented series. There was considerable heterogeneity, and patients with primary osteoarthritis appeared to have poorer outcomes than those with rheumatic diseases or other underlying hip diseases. However, it should be remembered that in some countries uncemented implants are used for all young patients, and therefore it seems unlikely that this factor biased our conclusion. Unfortunately, long-term results of the newer generation uncemented implants are not yet published. We identified 9 studies of uncemented THA that had a minimum mean follow-up of 10 years\textsuperscript{10, 26-33}. Only one met the NICE criteria, but this related to custom made prosthesis in low demand patients. Two important studies that did not fulfill the inclusion criteria deserve discussion. Kim et al. reported a series of 118 hips in 80 patients with a mean follow-up of 9.8 years\textsuperscript{34}. This study demonstrated survival of an uncemented hip of 99%. These results are likely to fulfill the NICE criteria in the future. However, there was a very high rate of polyethylene wear. The other study which merits attention is that of McAuley et al.\textsuperscript{6}. The average follow-up was only 6.9 years. In the study they report a calculated survival rate of 89% at 10 years, approaching the NICE criteria. This study reported 561 uncemented THAs in 488 young patients. The mean age of was 40 years (16-50 years). The main indications were osteoarthritis (249 hips) and osteonecrosis (111 hips). The survival rate at 15 years in their cohort was 60% with the endpoint being revision for any reason. A survival rate of >90% after a mean of 10 years is not a guarantee of good very long-term survival. For example, Emery et al.\textsuperscript{12} demonstrated implant survivorship of 90% at 10 years, just fulfilling the criteria. After 15 years survivorship was 68%, a decrease of 22% in 5 years. Survival data for cemented THAs naturally has a greater retrospective reach, and has been reported as 60% after 30 years (Keener et al.\textsuperscript{14}), 75% after 20 years (Joshi et al.\textsuperscript{13}), again 75% after 20 years (Devitt et al. (35)) and 73% at 20 years (Sochart and Porter\textsuperscript{20, 21}). The longest duration for uncemented reported survivorship (endpoint revision for any reason) at 15 years is 60% (McAuley et al.\textsuperscript{6}). Although uncemented implants have been used for over 25 years, most first generation implants were abandoned. Modern uncemented implants incorporate improvements in design, but they have yet to confirm their efficacy by long-term
follow-up. Some 2nd and 3rd generation uncemented implants have demonstrated good short-term results, such as the series reported by Delaunay et al.36. After a mean follow-up of 7.3 years they reported implant survival of 100%. Kennedy et al.37, observed implant survival of 94% after 5 years, with a mean follow-up of 7.5 years. The Swedish hip register confirms the poorer outcome of all arthroplasties in patients under 50 years of age. The survivorship of uncemented implants is inferior to cemented implants, but these observations of large cohorts of patients may be biased because older implants with inferior outcomes may overshadow better results of some newer prostheses. Unfortunately, no detailed information about individual implants used in young patients is available in the Swedish register. In recent years, a variety of alternative bearing surfaces have become available. Highly cross-linked polyethylene, ceramic and metal bearings may influence implant survivorship in future. Nevertheless, the outcome of both cemented and uncemented THA in young patients continues to be disappointing. Most literature which fulfils the criteria of survivorship of ≥90% after 10 years is based on cemented implants. The long-term results of newer uncemented implants are necessary to support their use in young patients.

**Acknowledgements**

We would like to acknowledge Jan Hendriks, PhD for his support in the statistical analysis and Gerjon Hannink for reviewing the manuscript.
References


Chapter 9

Cost-effectiveness of cemented versus uncemented total hip arthroplasty

A cemented cup with acetabular impaction bone grafting is a very cost-effective treatment option in young patients

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Adang EM
Lie SA
Havelin L
Schreurs BW

Submitted
Abstract

Background: Acetabular deficiencies in young patients in need for THA can be restored in several ways during total hip arthroplasty.

Questions/purposes: Impaction bone grafting of acetabular defects is a biological approach, but is it cost-effective on the long term?

Methods: We designed a decision model for a cost-utility analysis of a cemented cup with acetabular impaction bone grafting versus an uncemented cup, in terms of cost per quality-adjusted life year (QALY) for the young adult with acetabular bone deficiency, in need for a total hip arthroplasty. Outcome probabilities and effectiveness were derived from the Radboud University Nijmegen Medical Centre and the Norwegian Hip Register. Multiple sensitivity analyses were used to assess the contribution of the included variables in the model’s outcome.

Results: Cemented cups with impaction bone grafting were more cost-effective compared to the uncemented option in terms of costs per QALY. A scenario suggesting equal primary survival rates of both cemented and uncemented cups still showed an effect gain of the cemented cup, but at higher costs.

Conclusions: Based on this model, the first choice of treatment of the acetabular bone deficient osteoarthritic hip in a young patient is reconstruction with impaction bone grafting and a cemented cup.
Background and purpose

Cost-effectiveness of orthopaedic procedures is of growing importance. Total hip arthroplasty (THA) has proven to be a very cost-effective procedure\(^1\)\(^2\). However, young patients often outlive their implant. Particularly in these young patients, we need techniques and hip prostheses with a favourable long-term outcome\(^3\)\(^4\) as they are at great risk for revision. The outcome of both primary and revision surgery plays an important role in the cost-effectiveness of treatment of these patients. Clearly, the cup is the weakest link of THA\(^5\)\(^6\). Young patients with hip osteoarthritis often have acetabular bone stock defects at their primary surgery due to underlying diseases, which may hamper the longevity of the cup even more. Uncemented hip designs have gained worldwide popularity and are the first choice of treatment in young patients at the moment, also in case of acetabular defects. IBG in combination with a cemented cup is another treatment option for these young patients\(^7\) in which the deficient acetabular bone stock is restored. Excellent long-term survival data of this technique are reported\(^8\)-\(^13\) including long-term data of revision cases\(^14\)-\(^16\). However, this biological approach of reconstructing the osteoarthritic hip is time-consuming in theatre and is technically more demanding.

We hypothesize that for young patients, the efforts of acetabular impaction bone grafting and a cemented cup are beneficial and justified on the longer term compared to the use of uncemented cup designs without grafting.

Patients and methods

Economic modelling

We have designed a decision model (Figure 1) to determine the cost-effectiveness of acetabular impaction bone grafting. The model has two modalities for the young patient with an acetabular defect and hip osteoarthritis: a cemented cup with acetabular impaction bone grafting versus an uncemented cup. We have expressed our findings in terms of costs, quality-adjusted life years (QALYs) and incremental costs per QALY gained. In the Netherlands, an incremental cost-effectiveness ratio (ICER) of less than 80,000 Euros is generally thought to be cost effective by policy makers, depending on the burden of the underlying illness\(^17\).
Fig. 1: Markov Model

Markov model with cycles of one year to estimate QALYs and costs accumulating over a time period of fifteen years.
We have constructed a discrete-state Markov model similar to Spiegelhalter\textsuperscript{18} and modified the model to approach the actual situation of a young adult in need for a hip replacement. The model has cycles of one year to estimate QALYs and costs accumulating over a time period of fifteen years from a hospital perspective, discounted at a standard annual rate of three percent for both QALYs and costs. The first two treatment branches consist of a cemented cup with impaction bone grafting and an uncemented cup. The branching points thereafter represent transition to a different health state. Table 1 illustrates a transition matrix underlying the Markov model with the key health states (survival, post revision THA, post revision THA II, post revision THA III and death) and possible transitions between them during each cycle.

<table>
<thead>
<tr>
<th>Markov States</th>
<th>Successful THA</th>
<th>Post revision THA</th>
<th>Post revision THA II</th>
<th>Post revision THA III</th>
<th>Dead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Successful THA</td>
<td>P1</td>
<td>P2</td>
<td>0</td>
<td>0</td>
<td>P3</td>
</tr>
<tr>
<td>Post revision THA</td>
<td>0</td>
<td>P4</td>
<td>P5</td>
<td>0</td>
<td>P6</td>
</tr>
<tr>
<td>Post revision THA II</td>
<td>0</td>
<td>0</td>
<td>P7</td>
<td>P8</td>
<td>P9</td>
</tr>
<tr>
<td>Post revision THA III</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>P10</td>
<td>P11</td>
</tr>
<tr>
<td>Dead</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>P12</td>
</tr>
</tbody>
</table>

P1 to P12 are the transition probabilities calculated based on the model.

Overall, through our model we considered a hypothetical population aged thirty-seven years or older in need for a hip replacement. We have constructed our model in TreeAge pro Suite 2009 (Williamstown, USA) and assessed it by two-dimensional Monte Carlo simulation. We ran our model for sixteen cycles. We calculated the time spent in each health state and by attributing costs and quality of life weights to each health state. Total costs and QALYs were established for each of the treatment options.

As we were interested in long-term results of both techniques, we have incorporated survival of revision surgeries with accompanying costs.
Uncertainty

Our model took into account the uncertainty around several input parameter point estimates, which are listed in Table 2a. We defined a probability distribution of such a model input parameter on the basis of its point estimate and standard deviation (Gamma distribution) or range (Triangular distribution). We ran our model a thousand times, established through estimation of two-dimensional Monte Carlo simulation, running random trials and each time randomly selecting simultaneously a value for all the stochastic parameters from their respective distributions. We calculated mean costs and mean QALYs by averaging across all 1000 simulations. Furthermore, we did a sensitivity analysis to test the impact of the discount rate on the ICER. We also explored a scenario where primary survival of uncemented cups is made equal to cemented cups with impaction bone grafting. We have made several clinical assumptions and we discuss their possible impact on the model or their appropriateness (Table 2b).

<table>
<thead>
<tr>
<th>Table 2a: Input parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input parameter</strong></td>
</tr>
<tr>
<td><strong>Survival</strong></td>
</tr>
<tr>
<td>Survival rates primary cemented cups with impaction bone grafting</td>
</tr>
<tr>
<td>Survival first cemented cup revision with impaction bone grafting</td>
</tr>
<tr>
<td>Survival primary uncemented cups</td>
</tr>
<tr>
<td>Survival first uncemented cup revision</td>
</tr>
<tr>
<td>Survival 2th revision/year (cemented and uncemented THA)</td>
</tr>
<tr>
<td><strong>Costs (in Euro’s)</strong></td>
</tr>
<tr>
<td>Material costs cemented treatment</td>
</tr>
<tr>
<td>Material costs uncemented treatment</td>
</tr>
<tr>
<td>Hospital admission costs/day</td>
</tr>
<tr>
<td><strong>Miscellaneous</strong></td>
</tr>
<tr>
<td>Probability of peri-operative death (primary operation);</td>
</tr>
<tr>
<td>Probability of peri-operative death (revision operation)</td>
</tr>
</tbody>
</table>
Table 2b: Clinical assumptions and their appropriateness

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Appropriateness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survival rates</td>
<td>Derived from clinical data; high impact on final outcome, as shown in second scenario with equal survival rates.</td>
</tr>
<tr>
<td>Costs</td>
<td>We have calculated the costs as accurate as possible; high impact on final outcome.</td>
</tr>
<tr>
<td>Equal probabilities of infection, death and functional class after THA</td>
<td>We think this is an appropriate assumption with minor impact on the outcome.</td>
</tr>
</tbody>
</table>

### Survival data

Survival data were gathered of acetabular components in patients younger than 50 years at the time of primary surgery (Table 3). For the cemented option with impaction bone grafting we used data of a previously reported series of 42 acetabular reconstructions with a mean age of 37 years at the time of operation. Survival at 15 years was 84 % (95 % CI: 72-96 %) with failure for all reasons as the endpoint. For the first revision in our model, we have used survival data of 62 acetabular revisions in 58 patients with a mean age of 59 years. Survival at 15 years was 84 % (95 % CI: 70-92%) (revision for any reason).

For the uncemented option in the model, data were obtained from the Norwegian Arthroplasty Register. Unpublished data of 1289 patients younger than 50 years with primary hip osteoarthritis, who had received an uncemented cup, were analyzed and survival rates were determined (Table 3). The most commonly used cups were Trilogy (Zimmer), Tropic (Landos), Duraloc (DePuy) and Reflection uncemented (Smith&Nephew). The probability of survival of primary uncemented cups was 61% (95% CI: 57-65 %) at 15 years. Survival of the first uncemented cup revision was based on 76 patients and was 52% (95 % CI: 35-67 %) at 15 years. As survival rates of the cup solely were not available for the second revision, we used the same data for both cemented and uncemented revisions as presented by Lie et al, with a survival rate of 59,5 % (95 % CI: 54-65 %) at 10 years. Using power root transformation the yearly survival was calculated at 0,035. This was extrapolated to obtain a 15-year survival rate for the second revision. We made the assumption that after failure of the second revision a third revision was done.
### Table 3:
**Transition rates primary cups**

<table>
<thead>
<tr>
<th>Follow up (years)</th>
<th>Probability of survival</th>
<th>Follow up (years)</th>
<th>Probability of survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.999250562</td>
<td>1</td>
<td>0.992262513</td>
</tr>
<tr>
<td>2</td>
<td>0.973678425</td>
<td>2</td>
<td>0.992670263</td>
</tr>
<tr>
<td>3</td>
<td>0.99150722</td>
<td>3</td>
<td>0.984153261</td>
</tr>
<tr>
<td>4</td>
<td>0.998951101</td>
<td>4</td>
<td>0.984019486</td>
</tr>
<tr>
<td>5</td>
<td>0.999000999</td>
<td>5</td>
<td>0.977123523</td>
</tr>
<tr>
<td>6</td>
<td>0.971897783</td>
<td>6</td>
<td>0.965153817</td>
</tr>
<tr>
<td>7</td>
<td>0.998552099</td>
<td>7</td>
<td>0.972251185</td>
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<tr>
<td>8</td>
<td>0.969980231</td>
<td>8</td>
<td>0.948415917</td>
</tr>
<tr>
<td>9</td>
<td>0.998452399</td>
<td>9</td>
<td>0.967455365</td>
</tr>
<tr>
<td>10</td>
<td>0.998153416</td>
<td>10</td>
<td>0.946107059</td>
</tr>
<tr>
<td>11</td>
<td>0.96874379</td>
<td>11</td>
<td>0.957199658</td>
</tr>
<tr>
<td>12</td>
<td>0.967623698</td>
<td>12</td>
<td>0.944124718</td>
</tr>
<tr>
<td>13</td>
<td>0.997406742</td>
<td>13</td>
<td>0.936720462</td>
</tr>
<tr>
<td>14</td>
<td>0.96499208</td>
<td>14</td>
<td>0.943993804</td>
</tr>
<tr>
<td>15</td>
<td>0.963727695</td>
<td>15</td>
<td>0.932704963</td>
</tr>
</tbody>
</table>

**Abbreviations:** * data from Norwegian Arthroplasty Register

### Table 4:
**Transition rates revision cups**

<table>
<thead>
<tr>
<th>Follow up (years)</th>
<th>Probability of survival</th>
<th>Follow up (years)</th>
<th>Probability of survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.993739442</td>
<td>1</td>
<td>0.949016676</td>
</tr>
<tr>
<td>2</td>
<td>0.99290076</td>
<td>2</td>
<td>0.942351298</td>
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<tr>
<td>3</td>
<td>0.992161921</td>
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<td>0.932667282</td>
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<tr>
<td>4</td>
<td>0.991620804</td>
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<td>0.966830284</td>
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<td>5</td>
<td>0.97311066</td>
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<td>0.866132348</td>
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<tr>
<td>6</td>
<td>0.90000099</td>
<td>6</td>
<td>0.951919181</td>
</tr>
<tr>
<td>7</td>
<td>0.989707047</td>
<td>7</td>
<td>0.907243594</td>
</tr>
<tr>
<td>8</td>
<td>0.968902401</td>
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<td>0.939232149</td>
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<td>9</td>
<td>0.987703096</td>
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<td>0.929612731</td>
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<tr>
<td>10</td>
<td>0.963835319</td>
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<td>0.920987316</td>
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<td>11</td>
<td>0.936607051</td>
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<tr>
<td>12</td>
<td>0.956665824</td>
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<td>13</td>
<td>0.954551432</td>
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<td>0.983475777</td>
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<tr>
<td>14</td>
<td>0.980969198</td>
<td>14</td>
<td>0.980969198</td>
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<tr>
<td>15</td>
<td>0.979527868</td>
<td>15</td>
<td>0.979527868</td>
</tr>
</tbody>
</table>

**Abbreviations:** * data from Norwegian Arthroplasty Register
Costs

The costs of an intervention consisted of material costs, costs of operation theatre and costs of hospital admission. The material costs are based on a total cemented or total uncemented hip arthroplasty. For calculation of the costs of the cemented option with acetabular impaction bone grafting, we used data of 79 most recently operated patients younger than fifty years in the period 2007 - 2010 at the Radboud University Medical Centre Nijmegen (Table 5).

### Table 5: Costs (in Euros)

<table>
<thead>
<tr>
<th></th>
<th>Cemented</th>
<th>Uncemented</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material costs primary THA (range)</td>
<td>2086 (1633-2784)</td>
<td>2675 (2112-3355)</td>
</tr>
<tr>
<td>Material costs revision THA (range)</td>
<td>3086</td>
<td>4382 (3816-4703)</td>
</tr>
<tr>
<td>Theatre costs primary THA</td>
<td>1623</td>
<td>1096</td>
</tr>
<tr>
<td>Theatre costs revision THA</td>
<td>1980</td>
<td>1452</td>
</tr>
</tbody>
</table>

Costs of the uncemented option were calculated as if they were performed at the Radboud University Medical Centre Nijmegen. To minimize the possibility of selection bias regarding costs of uncemented hip arthroplasty, we have averaged the registered prices of three very commonly used uncemented total hip designs in the Netherlands (Table 5). The mean operation time of cemented hip arthroplasty using impaction bone grafting was 123 minutes and we assumed that an uncemented hip arthroplasty at our hospital would take 40 minutes less (20 minutes for the impaction bone grafting procedure, two times 10 minutes for cementation). This assumption was made for both primary and revision operations. The costs of all revisions were assumed to be equal.

Mean duration of hospital admission for a cemented hip arthroplasty using impaction bone grafting at our institute was 7.2 days. We assumed that the length of stay in hospital of patients with an uncemented hip arthroplasty was 5 days, which is in concordance with previous data20. Hospital admission time was set at ten days for all revision cases. Hospital costs were adapted from the Dutch Guidelines to Costs in Medical Care21. We assumed that other costs (indirect costs) like visits to outpatients’ clinic, radiological review, laboratory testing and physiotherapy were equal for both cemented and uncemented treatments and we have decided not to include these in our model.
Utilities  
Effectiveness is expressed in QALYs gained. Health-related quality of life was determined by a functional class as being used by the American College of Rheumatology\textsuperscript{22}. Harris Hip Scores were converted to the functional classes (Table 6) by the system described by\textsuperscript{23}. No difference between cemented and uncemented hip arthroplasty was made for the division of functional classes. The following assumptions were made: patients with successful cemented or uncemented implants have the same utility or QALY value after the initial postoperative period. The mortality rates of patients who survived their hip surgery do not differ from the age-adjusted mortality rates of patients without a hip prosthesis implanted, as calculated by Statistics Netherlands (CBS) life-tables\textsuperscript{24}. Mortality rates of the life-tables were used starting at the age of 37.5 and 59.5 for the primary surgery and the first revision, respectively. These numbers are based on mean ages at surgery of the patients in our cemented series as described above. For the second revision, data starting at the age of 74.5 was used. Probability of death was assumed equal for both the cemented and the uncemented branch. Regarding determining infection rate\textsuperscript{25} after primary and revision arthroplasty, we assumed there was no difference between older and younger patients and no difference between cemented and uncemented prostheses.

| Table 6: Conversion of Harris Hip Scores to Quality of Life (HRQOL) |
|-------------------|-------------------|-------------------|
| Outcome           | Harris Hip Score  | HRQOL             |
| Excellent         | 90-100            | 1                 |
| Good              | 70-89             | 0.8               |
| Fair              | 40-69             | 0.5               |
| Poor              | <40               | 0.3               |

<table>
<thead>
<tr>
<th>Table 7: Incremental cost-effectiveness ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario</td>
</tr>
<tr>
<td>Basecase</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equal survival</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Results

The point estimate of the incremental cost-effectiveness ratio (ICER) in the baseline scenario shows that a cemented cup with impaction bone grafting is more cost-effective compared to the uncemented option, in terms of costs per QALY. When exploring the scenario in which survival rates of primary uncemented cups are made equal to primary cemented cups with IBG, the point estimate of the ICER
becomes €43,500 per QALY gained (Table 7). Through incorporating uncertainty in the analyses, the results of both scenarios are presented as an incremental cost-effectiveness plane (Figure 2) and as a cost-effectiveness acceptability curve (CEAC) (Figure 3). In these figures, the uncemented option is always the baseline comparator.

In the baseline scenario almost 90% of the simulated ICERs lay in the southeast quadrant meaning that a cemented cup plus IBG is the most cost-effective option (Figure 2). About 10% of the simulations fall in the northeast quadrant, implying a trade-off between extra costs and extra effects. So, in 10% of the simulations, a gain in QALY’s is still seen using cemented cups with IBG but at higher costs.

The second scenario suggesting an equal survival of cemented and uncemented
cups still shows an effect gain for cemented cups plus IBG, however at an extra cost (on average the more expensive solution). So, patients still have a rise in QALY’s on the longer term but at higher costs compared to an uncemented cup.

Figure 3 shows in the baseline scenario that if ‘policymakers’ are willing to pay a small amount of money for a QALY gained (more than 0 Euro) policymakers can be 90% confident that a cemented cup plus IBG is the most cost-effective option. The other scenario shows that the willingness to pay has to be more than €80,000 for policymakers to be about 80% confident that a cemented cup plus IBG is the most cost-effective option. Varying the discount rate in the baseline scenario over the range [0,5%] showed that cemented plus IBG option kept dominating the uncemented option and was still the most cost-effective option. In the alternative scenario, the ICER was sensitive to alterations in the discount rate. A higher discount rate resulted in a worse outcome (higher ICER).

**Discussion**

As we were interested in the cost-effectiveness of acetabular impaction grafting to treat the bone deficient osteoarthritic hip in a young patient, we have designed a model comparing two modalities: a cemented cup with grafting versus an uncemented cup. It shows that on the longer term, impaction bone grafting with a cemented cup is more cost-effective than the use of an uncemented cup.

The current trend to use uncemented cups in young patients seems not to be supported in literature.5 Regarding costs, a recent study on data of the National Joint Registry shows that a possible cost saving to the NHS of more than 18 million pounds per year can be made if cemented instead of uncemented hip designs were used in England and Wales.26 Another recent study on cost-effectiveness of different types of total hip replacements in older patients concludes that uncemented prostheses do not improve health outcomes sufficiently to justify their higher costs.27 These studies confirm our findings in the way that uncemented hip designs are less cost-effective compared to cemented total hip prostheses.

A strength of our study is that in our model we acknowledge the fact that the technique of impaction bone grafting takes additional time and materials and
we have included these costs in our model. Other strengths are the fact that we have incorporated three revisions with accompanying costs in our model and we have used advanced statistical software (TreeAge pro Suite 2009) to construct our model. A point of criticism on our study could be that the survival rates of primary uncemented cups are worse than the rates of cemented cups. However, these numbers were derived from the reliable Norwegian Arthroplasty Register and constitute a consecutive series of young patients treated with uncemented cups.

We are aware of the fact that our study is based on hip designs used several years ago and that nowadays articulations with highly cross-linked polyethylene are more commonly used than conventional polyethylene. However, long term results of uncemented cups with highly cross-linked polyethylene are not available. To overcome criticism on these limitations in our model, we have explored a scenario in which the survival rates of primary uncemented cups are made equal to primary cemented cups with impaction bone grafting. In this scenario, an effect gain for a cemented cup with impaction bone grafting was still seen, but at higher costs. So, even with equal survival rates for both acetabular options, reconstruction of an acetabular defect with impaction bone grafting and a cemented cup seems to be beneficial on the long term. Another limitation of our study might be that costs of treatments and materials may differ between hospitals and that some hospitals may have arranged lower prices. We realise this could be a limitation in applying the conclusions of this study to other hospitals. Nevertheless, costs were calculated as if all prostheses were placed in our hospital without any discounts, to have a baseline comparator of the 2 techniques. The advantage of this model is that the input can be updated with new information in the future.

We have optimized the parameters of the uncemented option by not taking into account any additional material costs for dealing with bone defects or periprosthetic fractures, which are more common using uncemented designs or at uncemented revision operations. Also the estimation of length of stay is in favour of uncemented hip arthroplasty. Besides this, we have compared survival data of cemented cups in difficult cases with acetabular defects to data of uncemented cups without the need for acetabular reconstruction, which might be of positive influence on the outcome of the uncemented treatment. Even using these data, cemented hip arthroplasty with impaction bone grafting is still more cost-effective than the uncemented option in young patients.
Patients with acetabular defects however could have been less active because of an underlying disease, which might have contributed to high survival rates of the cemented cases. As we know that higher levels of activity are of negative influence on survivorship of THA\textsuperscript{28}, we have measured the polyethylene wear of cemented sockets with impaction bone grafting and an average wear rate of 0.08 mm/year was seen. These wear rates are in concordance with rates of cemented sockets with impaction bone grafting of larger patient populations previously reported\textsuperscript{11}. This suggests the study group was equally active and representative for young patients in need for a THA. However, higher wear rates using conventional polyethylene liners are reported in young patients\textsuperscript{29} so adding an activity score to clinical scores in future will be a more accurate way to measure activity levels.

We realize that the first step in our model is based on a small group of forty-two cemented cases with acetabular impaction bone grafting. Recently however, we have analysed all patients younger than fifty years (177 hips) that underwent acetabular impaction bone grafting in our department and survivorship of the cup at 15 years was 80.7 % with revision for any reason as the end point. This strengthens the data used in the present model. In addition, the survival of the cups reconstructed with bone impaction grafting in patients under forty years\textsuperscript{11} also supports the survival data used in the present study and these are two independent data sets. We are aware of studies that show less favourable results of acetabular impaction bone grafting, especially those evaluating reconstruction of larger acetabular defects\textsuperscript{30}. This means that the outcome of this model might not be translated to other institutions where the technique and circumstances are different. On the other hand, other reports show high success of the same technique\textsuperscript{14,15}. Reported survival rates vary, as survival rates of other techniques like uncemented series do.

Especially in young patients, treatments with higher initial costs can be more cost-effective when survival rates turn out to be high. We have modelled three revisions and recognized the functional outcomes of patients after revision surgery are inferior to those of patients after primary hip replacement, as a major concern for young patients is the need for revision.

Cost effectiveness analysis of orthopaedic treatments may be a helpful tool in clinical decision-making for hospitals and health policy makers. In the present study, cemented cups with acetabular impaction bone grafting were more cost-effective
than uncemented cups in terms of costs per QALY for the young patient in need for a hip replacement with an acetabular defect. We recommend impaction bone grafting with a cemented cup for reconstruction of the bone deficient osteoarthritic hip in a young patient, as this seems to be a reliable alternative to the more commonly used uncemented cups.
References


General discussion, summary and conclusion
General discussion, summary and conclusion

The aim of this thesis is to determine the clinical outcome of THA in young patients and how to deal with acetabular defects. In this view, seven questions were formulated and these questions will be discussed in the current chapter.

1. How many hip arthroplasties are performed in young patients in the Netherlands and what types of hip prosthesis are most commonly used?

Chapter 2 presents the distribution of different types of hip designs currently used in the Netherlands as reported in the Dutch Arthroplasty register. In 2012, the number of yearly implanted total hip arthroplasties had risen to almost 25,000; the distribution of the different types is shown in Table 1 of Chapter 2. Around 5% of these patients were younger than 50 years at the time of operation and more than 75% of all hip replacements in these young patients were uncemented designs (Fig. 2 in Chapter 2). The use of uncemented hip implants has increased over the years. The National Joint Registry of England and Wales reported that of all procedures in 2005, 22% were uncemented designs whereas in 2011 this figure had grown to 41% in patients of all ages. In patients younger than 50 years, uncemented hip replacements accounted for approximately 64% of females and 60% of males. These rates were approximately 16% in females and 12% in males for cemented hip designs. The remaining 20% of females and 28% of males in this age group received a hybrid construction of resurfacing hip prosthesis.

The Swedish Hip Arthroplasty Register has also shown a slight increase in the use of uncemented implants, but cemented implants are still used for more than 80% of cases, regardless of the patient’s age. Between 1992 and 2011, a shift towards the use of uncemented implants and hybrid constructions can be seen in the younger age group.

In Norway, reversed hybrid constructions with a cemented acetabulum and an uncemented stem have been performed more frequently in the age group under 60 years.
In general, we conclude that it is an international trend to use uncemented hip designs and components in young patients. In Chapter 8 we will discuss whether this trend is in agreement with the clinical evidence.

2. What is the outcome of cemented THA in very young patients under 30 years?

Chapter 3 shows the outcome of 48 patients (69 THAs) younger than 30 years who had a primary cemented THA performed between 1988 and 2004. Acetabular defects have been reconstructed using bone impaction grafting in 29 hips. Mean age at surgery was 24.6 (16-29) years. No patient was lost to follow-up but three patients with four THAs had died. The mean Harris Hip Score (HHS) of the 57 surviving THAs in 37 living patients was 89 (55–100) and the mean Oxford Hip Questionnaire Score (OHQS) was 19 (12–42) after a minimum follow-up of 2 years (mean 8.4 years; range 2–18 years). Eight hips were revised after a mean follow-up of 8.4 (2-18) years, three for infection and five for aseptic loosening. One additional cup was considered a radiographic failure. Survival was 83% with revision for any reason and 90% with revision for aseptic loosening as the end point after 10 years of follow-up. Especially in these very young patients, we need techniques and implants with demonstrated long-term success. Reviewing the available literature on the outcome of THA in these young patients under 30 years (Table 4 in Chapter 3) we have presented an acceptable survival for cemented THA, keeping in mind that most failures are seen of the acetabular component. In case of an acetabular defect at primary surgery, we recommend acetabular impaction bone grafting to restore bone stock.

3. What are the radiographic and clinical results of acetabular impaction bone grafting in patients younger than 50 years at long-term follow-up?

Acetabular defects are often seen in young patients with secondary osteoarthritis of the hip and several treatment options exist. In Chapter 4 and 5, we
have investigated whether impaction bone grafting in combination with a cemented cup to reconstruct acetabular defects is a durable long-term solution. We studied 42 consecutive acetabular reconstructions in 37 patients younger than 50 years old (average 37.2 years) at the time of operation. Twenty-three primary and 19 revision operations had been performed. The mean follow-up was 23 (20-28) years and at final review one patient was lost to follow-up and 8 patients (10 hips) had died. Sixteen cups had been revised, 2 because of septic loosening and 8 because of aseptic loosening. Another 4 cups had been revised because of wear and osteolysis and 2 cups during a stem revision but these were found to be well-fixed. Survival of the acetabular reconstructions, with end point revision for any reason, was 73% after 20 years and 52% after 25 years. With revision for aseptic loosening as the end point, survival was 85% after 20 years and 77% after 25; for signs of loosening on radiographs, survival was 71% at 20 years and 62% at 25 years.

At present, uncemented cups are most frequently used in young patients, but long-term reports on uncemented cups with bone grafting in young patients are lacking in the literature. Good mid-term results have been presented in older patients however, Rudelli et al.\textsuperscript{5} showed a survival rate of 88% of uncemented cups, with an end point revision for any reason, after a mean follow-up of 14 years in a group of 42 patients (43 THAs) with a mean age at surgery of 56 years. Palm et al.\textsuperscript{6} reported a 9-year survival rate of the cup of 90.5% in a group of 79 patients in whom the median age was 67 years. Lachiewicz and Poon\textsuperscript{7} have reported the results of 34 patients in whom morselized bone grafts had been used in combination with a Harris-Galante porous-coated cup, and no revision because of loosening had taken place after a mean follow-up of 7 years. Although these are good and promising mid-term results, longer follow-up is needed to demonstrate the true clinical value of these uncemented techniques in young patients.

Over time, the results of cemented cups with acetabular impaction bone grafting have deteriorated. However, this study is one of the few worldwide available describing results of THA in young patients with a mean follow-up of 23 years. The technique of using impacted morselized bone graft in combination with a cemented cup is useful to restore bone stock in young patients whose acetabular defects require primary or revision total hip arthroplasty.
4. What is the outcome of acetabular solid grafting in DDH-patients?

Socket fixation in patients with acetabular dysplasia can be technically demanding. Most surgeons try to restore the centre of hip rotation and in most cases this is possible with a standard cup. In the more severe cases however, bone stock may not be sufficient to support a standard cup, which makes reconstruction of the acetabulum necessary. Several options are available, including impaction bone grafting which has been discussed in previous chapters. In patients with DDH, this technique has been shown to be effective with high long-term survival rates. However, structural or solid grafts can also help to reconstruct the original centre of hip rotation and restore normal hip biomechanics. In Chapter 6 we have described the results of 62 patients with DDH who had 74 cemented THAs with solid acetabular roof grafts. Mean age at surgery was 45 years (range 19-71 years) and the mean follow-up was 10.4 years (range 5-16 years). Patients with grafting had higher Oxford scores compared with the control group (p=0.04) but other scores were equal. A scientific explanation for this difference could not be found. It might be that the improvement of the score was higher in grafted patients but unfortunately, pre-operative scores were not available. Two hips were revised for aseptic acetabular loosening and one hip for polyethylene wear. All grafts were incorporated and no additional radiographic loose cups were seen. The survival rate at 10 years of follow-up for revision for any reason was 98% (95% CI, 92.5%-100.0%). Although high failure rates have been presented in literature, these survival rates are comparable to other series of patients with DDH receiving acetabular structural grafting that show high survival rates (Table 4 in Chapter 6).

The treatment protocol followed in Edinburgh for dysplastic hips is a biologically attractive approach, resulting in restoration of bone stock in these relatively young patients. Although some authors recommend avoiding structural bone grafts if possible, bulk grafts for reconstruction of acetabular defects have shown to provide additional value for future revisions. We assume that survival of the reconstruction is mainly determined by the preparation and fixation of the graft. The technique was originally described by Wolfgang and further described by Iida et al. and has been performed the same way throughout this study. A wedge of the femoral head is taken and fixed with two cancellous screws with its sclerotic convex side towards the defect as an inlay graft (Figure 1 in Chapter 6). In the early
years, three cancellous screws were used for fixation of the graft. Later it has been shown that two screws are sufficient. In contrast to the reported series we found high survivorship of cemented sockets with roof graft in severe acetabular dysplasia with a mean follow-up of more than 10 years. Solid grafting in case of an acetabular defect can offer a durable solution for patients with DDH.

5. What are the radiographic and clinical results of uncemented THA in patients younger than 50 years?

Currently, uncemented THA seems to be the most popular solution for young patients with degenerative hip disease. Chapter 7 describes the long-term results of 73 consecutive Zweymüller total hip arthroplasties with a titanium threaded cup and a polyethylene insert in 67 patients aged under 50 years (mean 43 years, range 23-49). Three patients (3 hips) had died and an additional 7 patients (8 hips) without any reoperation had no radiographic follow-up. After a mean follow-up of 17.5 (range, 15-21) years, 3 hips had been revised for septic loosening, one for a periprosthetic fracture and 3 cups for aseptic loosening. The mean HHS was 90 (52-100) and the mean Oxford Score was 22 (14-43). Survival with an end-point of revision for any reason was 89% (95% C.I. 85-93) and of revision for aseptic loosening was 94% (C.I. 95-99) at 17 years. In a worst-case scenario for the cup where radiological failures were included and patients without a recent radiograph were considered failures, the survival rate was 84% (CI 81-87%) at 17 years. This compares favourably to other reported survival rates of uncemented cups in young patients. Aldinger et al\textsuperscript{13} showed high survival rates of a grit blasted femoral component, but low survival rates (38% and 68% at 17 years) of two types of smooth-surface threaded cups which are now no longer in use. It seems that porous-coating of a threaded cup to promote bony in-growth is essential to achieve stability and higher survival rates at longer follow-up. A study of 83 cementless Zweymüller Alloclassic stems with a 28 mm metal-on-metal bearing in 73 young, active patients showed excellent results\textsuperscript{14}. Only patients with high activity levels were selected for review; patients with severe dysplasia and rheumatoid arthritis were excluded. Three different acetabular components had been used of which 24 were titanium threaded. This series of patients showed a 10-year survival rate of 100% (CI 89.6-100%).
Eskelinen et al.\textsuperscript{15} concluded in a nationwide study on THA in patients younger than 55 years that survival rates of uncemented cups are unsatisfactorily low when liner exchanges are taken into account. We acknowledge the fact that many types of uncemented hip designs are available which makes comparison between groups of implants difficult. In chapter 7 we describe the results of the Zweymüller total hip prosthesis with a titanium threaded cup. In this series of young patients, high survival rates were achieved at 17 years of follow-up.

6. Are the hip implant-choices for young patients in The Netherlands evidence-based?

As many types of THAs exist to treat young patients with degenerative hip disease, we have reviewed the available literature on this topic to determine the optimal treatment. Results of this review are given in Chapter 8. We examined all reported outcomes of uncemented and cemented total hip arthroplasty in patients younger than 50 years of age listed in Medline between 1966 - 2009 as well as those mentioned in PubMed. In addition we scrutinised the reference lists of relevant papers. Data provided by the Swedish Hip Arthroplasty Register\textsuperscript{3} were evaluated: 109 relevant articles were identified, 37 of which had a mean follow-up longer than 10 years. Although uncemented implants are widely used in patients under 50 years of age, at the time of this study only 2 reports fulfilled the criteria of survival by 90\% at the 10-year follow-up, as recommended by the National Institute for Clinical Excellence (NICE)\textsuperscript{16}. Cemented implants have been in use for a longer period with many studies meeting the survival criteria (Table 1 in Chapter 8). A confusing factor in assessing studies of uncemented hips is that revision of a failed insert of an uncemented acetabular metal shell has not always been reported as a revision. Thus, discrepancies in the reported outcome may exist. A critical note concerning the survival rates as reported by National Registries could be that many different types of uncemented hip designs have been gathered and the poorer outcome of those implants with an inferior survival may obscure the outcome of those designs with a better performance. This study concluded that the highest survival rates were related to cemented implants; thus the current trend to use uncemented implants has not yet been supported by the available literature.
7. What is the most long-term cost-effective treatment of a young patient in need for a THA?

Total hip arthroplasty has proven to be a cost-effective procedure in older patients\textsuperscript{17}. In young patients however, clinical outcome is less favourable and costs for future revisions should be included when calculating long-term costs. We did a cost-effectiveness analysis based on a health care perspective to compare two modalities for the young patient with symptomatic osteoarthritis. We have designed a decision model for a cost-utility analysis for a cemented cup with acetabular impaction bone grafting versus a cementless cup, in terms of cost per quality-adjusted life year (QALY). The model and its outcomes are presented in Chapter 9. Outcome probabilities and effectiveness were derived from the Radboud University Medical Centre and the Norwegian Hip Register. Cost data were gathered at the Radboud University Medical Centre. Multiple sensitivity analysis was used to assess the contribution of the variables included in the model's outcome. Cemented cups with impaction bone grafting dominate the cementless cup option in terms of costs per QALY. A scenario suggesting equal primary survival rates of both cemented and cementless cups continues to show an effect gain for the cemented cup but at a higher cost.

Remarkably, choices of hip implant differ greatly among hospitals and the criteria for these choices are not transparent. Costs of implants determine the cost-effectiveness to a large degree. A recent study on data from the British National Joint Registry shows that a possible cost saving to the NHS of more than 18 million pounds per year could be made if cemented instead of cementless hip designs were to be used in England and Wales\textsuperscript{18}. Criteria for choices of implants should become more transparent as costs play an important role in cost-effectiveness of THA. Obviously, initial costs are not the only factor because treatments with higher initial costs may be more cost-effective if the survival rates turn out to be higher. We have modelled three subsequent revisions and recognized that the functional outcomes of patients after revision surgery are inferior to those of patients after primary hip replacement. Because the possibility of a revision is a major concern for young patients, such costs should be included in the analysis. With this model we have provided a helpful tool for clinical decision-making for hospitals and health policy makers. In the present study, cemented cups with acetabular impaction bone grafting were more cost-effective than cementless cups in terms of costs per QALY for the young patient in need for a hip replacement.
Conclusion

Several options are available for treatment of the young patient with degenerative hip disease, but what the most durable solution is remains controversial. This thesis shows that good long-term results can be reached with both cemented and uncemented hip designs. However, to date the majority of papers with high survival rates are based on cemented hip designs. Although the initial outcome of our uncemented study is impressive, there is no information about the outcome of revisions. The debate whether cemented or uncemented THA would be the most durable solution for young patients is also blurred by the fact that results for many different hip designs have been gathered and evaluated as a group. Because we had to base our conclusion on the available literature we had to conclude that, in general, the cemented THA in young patients seems to be the most durable solution for young patients. Perhaps time is the only factor to show us otherwise.

Many different types of hip prostheses are currently used for young patients in the Netherlands. Recently, the Dutch Orthopaedic Association (NOV) published a list of approved hip designs*, classified according to their survival rates known from international registries (e.g. the Swedish Hip Arthroplasty Register) and available literature. We would like to plea for further standardization in the use of only well-performing hip designs in Dutch hospitals, especially in younger patients. In addition, concentration of treatment of “complex hips” by specialised surgeons enables them to build expertise in this field and this might optimize Dutch orthopaedic care for young patients with degenerative hip disease.

With regard to acetabular defects in young patients, we can conclude that it appears that a biological reconstruction is the most durable option as these patients probably face a second or third operation. Reconstruction using grafts, whether solid or morselized, is the preferred method, in combination with a cemented cup. From an economical point of view, reconstruction using impaction bone grafting and a cemented cup is more cost-effective compared to a primary uncemented cup as shown in Chapter 9. We hope that the outcome of this thesis will play a role in decision making by hospitals and orthopaedic surgeons when choosing the most preferable prosthesis in young patients.

*available online at http://www.orthopeden.org/uploads/ZA/rV/ZA/rVe9kJSozX79e0P8yJW4w/Advies-NOV-bestuur-over-het-gebruik-van-primaire-heuprothesen-10-feb-2013.pdf
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1. Data obtained from the database of the Dutch Arthroplasty Register (in Dutch: LROI).
2. National Joint Registry England and Wales, Annual Report of 2012, page 65, Figure 2.3. Available at www.njrcentre.org.uk


Chapter 11

Summary in Dutch/Nederlandse samenvatting
Het doel van dit proefschrift is om de klinische resultaten van een totale heupprothese bij jonge patiënten te beschrijven en om aan te geven hoe men het beste om kan gaan met botverlies van de heupkom (acetabulaire defecten). In dit kader werden zeven vragen geformuleerd die in dit hoofdstuk zullen worden besproken.

1. Hoeveel heupprotheses worden in Nederland geplaatst bij jonge patiënten en welke typen worden het meest gebruikt?

In 2007 is het Landelijk Register Orthopedische Implantaten (LROI) begonnen met de registratie van alle heup- en knieprothesen geplaatst in Nederland. Met behulp van deze data wordt in hoofdstuk 2 de verdeling beschreven van verschillende soorten heupprothesen die momenteel gebruikt worden in Nederland. Het aantal primair geplaatste totale heupprothesen is gestegen tot bijna 25.000 in 2012, waarvan ongeveer 5% werd geplaatst bij patiënten jonger dan 50 jaar. Grofweg bestaan er twee verschillende typen heupprothese op basis van fixatie aan het bot: met en zonder gebruik van botcement. Meer dan 75% van alle heupprothesen bij deze jonge patiënten waren van het ongecementeerde type (afbeelding 2 in hoofdstuk 2). Het gebruik van ongecementeerde heupimplantaten is toegenomen door de jaren heen. Het Nationale implantatenregister van Engeland en Wales meldde dat 22% van alle heupimplantaten geplaatst in 2005 van het ongecementeerde type waren. In 2011 is dit percentage gegroeid tot 41% bij patiënten van alle leeftijden. Bij patiënten jonger dan 50 jaar werd in meer dan 60% van de gevallen een ongecementeerde heupprothese geplaatst. In een veel kleiner percentage werd gekozen voor een gecementeerde heupprothese, namelijk 16% bij vrouwen en 12% bij mannen. In de overige gevallen werd gekozen voor een hybride constructie of een resurfacing heupprothese.

Het Zweedse heupregister toont ook een lichte stijging in het gebruik van ongecementeerde implantaten, maar gecementeerde implantaten worden nog steeds gebruikt in meer dan 80% van de gevallen (alle leeftijden). In de jongere leeftijdsgroep in de periode van 1992 tot 2011 is een verschuiving te zien naar het gebruik van ongecementeerde implantaten en hybride constructies.
In het algemeen kunnen we concluderen dat er een internationale trend bestaat om te kiezen voor ongecementeerde heupimplantaten voor jonge patiënten. In hoofdstuk 8 bespreken we of deze trend wordt ondersteund door bewijs in de beschikbare literatuur.

2. Wat zijn de resultaten van gecementeerde heupprotheses bij patiënten onder 30 jaar?

In hoofdstuk 3 worden de resultaten beschreven van 48 patiënten (met 69 heupen) jonger dan 30 jaar, bij wie een primaire gecementeerde heupprothese geplaatst werd tussen 1988 en 2004. In geval van een acetabulair defect vond opbouw plaats met botsnippers volgens de zogenaamde botimpactie techniek. De gemiddelde leeftijd bij operatie was 24.6 jaar (16-29 jaar). Alle patiënten werden gevolgd echter 3 patiënten (met 4 heupprothesen) zijn overleden. Na een gemiddelde follow-up van 8.4 (2-18) jaar waren 8 heupprothesen gereviseerd; 3 in verband met een infectie en 5 in verband met aseptische loslating. Bij 1 patiënt werd radiologisch loslating geconstateerd van de cup. De overleving van de heupprothese werd berekend volgens de Kaplan-Meier methode en was 83% met revisie voor alle redenen en 90% met revisie voor aseptische loslating als eindpunt na 10 jaar.

Met name zeer jonge patiënten die in aanmerking komen voor een heupprothese zijn gebaat bij een nieuwe heupconstructie met bewezen succes op lange termijn. In vergelijking met de beschikbare literatuur over heupprothesen bij patiënten onder 30 jaar (tabel 4 in hoofdstuk 3) worden goede resultaten gezien van de botimpactie techniek in combinatie met een gecementeerde heupprothese. In geval van een acetabulair defect raden wij herstel van botverlies aan met gebruik van de acetabulaire botimpactie techniek.

3. Wat zijn de resultaten op lange termijn van herstel van acetabulaire defecten door middel van de botimpactie techniek bij patiënten jonger dan 50 jaar?

Bij jonge patiënten met secundaire artrose van de heup worden regelmatig
acetabulum defecten gezien waarvoor verschillende behandelingsmogelijkheden bestaan. In hoofdstuk 4 en 5 hebben we onderzocht of reconstructie van deze defecten met behulp van geïmpacteerde botsnippers in combinatie met een gecementeerde cup een duurzame oplossing biedt voor de lange termijn. We hebben 42 opeenvolgende acetabulum reconstructies onderzocht in 37 patiënten die jonger waren dan 50 jaar ten tijde van operatie. Er werden 23 primaire en 19 revisie operaties uitgevoerd en de gemiddelde follow-up was 23 (range 20-28) jaar. Bij de laatste evaluatie bleek dat 8 patiënten (met 10 heupprothesen) waren overleden en dat één patiënt niet meer te traceren was. Er werden 16 acetabulum componenten gereviseerd: 2 vanwege septische loslating en 8 vanwege aseptische loslating. In 4 gevallen werd slijtage van de cup en osteolyse gezien en 2 cups werden gereviseerd tijdens een steelrevisie; tijdens de operatie bleek dat de laatstgenoemde cups goed gefixeerd waren. De overleving van deze acetabulaire reconstructie was 73% na 20 jaar en 52% na 25 jaar, met als eindpunt revisie voor alle redenen. Met revisie voor aseptische loslating als eindpunt was de overleving 85% na 20 jaar en 77% na 25 jaar. Met radiologisch falen van de reconstructie als eindpunt bleek de overleving 71% na 20 jaar en 62% na 25 jaar.

Bij jonge patiënten worden tegenwoordig vaak ongecementeerde cups gebruikt, soms in combinatie met botgrafts. Hiervan zijn goede resultaten beschreven op korte termijn maar langere follow-up is nodig om te zien of botgrafts met ongecementeerde cups een duurzame oplossing zijn voor de jonge patiënt.

Na verloop van tijd is de overleving van gecementeerde cups met acetabulaire opbouw met geïmpacteerde botsnippers duidelijk afgenomen. Dit is echter een van de weinige, wereldwijd beschikbare studies die resultaten van heupprothesen beschrijven bij jonge patiënten op deze lange termijn. Het gebruik van geïmpacteerde botsnippers is een nuttige techniek om acetabulaire botdefecten te herstellen bij jonge patiënten.

4. Wat zijn de resultaten van solide botgrafts om acetabulaire defecten te herstellen bij patiënten met congenitale heupdysplasie?

Fixatie van het acetabulaire component bij patiënten met heupdysplasie kan technisch een uitdaging zijn. Door de meeste chirurgen wordt gestreefd naar herstel
van het oorspronkelijke centrum van heuprotatie en vaak lukt dat met gebruik van een standaard cup. In ernstige gevallen kan het acetabulumdefect te groot zijn voor een standaard component en dan is een aanvullende techniek noodzakelijk. Er bestaan verschillende opties om deze defecten te herstellen en de techniek met geïmpacteerde botsnippers werd reeds in eerdere hoofdstukken besproken. Ook bij patiënten met heupdysplasie blijkt deze techniek effectief te zijn op de lange termijn. Een andere mogelijkheid om het oorspronkelijke centrum van heuprotatie te herstellen is het gebruik van een structurele of solide botgraft. In dat geval wordt een botblok gebruikt om het defect op te vullen waarna de cup geplaatst kan worden. In hoofdstuk 6 worden de resultaten beschreven van 62 patiënten met heupdysplasie bij wie 74 gecementeerde heupprotheses met solide acetabulaire grafts werden geplaatst. De gemiddelde leeftijd bij operatie was 45 (19-71) jaar en de gemiddelde follow-up was 10,4 (5-16) jaar. De studie vond plaats in Edinburgh in Schotland.

Twee heupprothesen werden gereviseerd vanwege aseptische loslating van de cup en 1 heupprothese voor slijtage van de cup. Alle botgrafts toonden goede ingroei en naast de gereviseerde cups werden geen radiologische loslatingen gezien. Uit analyse bleek dat patiënten met acetabulaire botgrafts hogere Oxford scores hadden vergeleken met de controlegroep (p = 0.04); andere scores waren gelijk. De overlevingskans van de constructie met solide grafts was na 10 jaar 98% met revisie voor alle redenen als eindpunt.

Hoewel eerder beschreven resultaten sterk wisselen zijn de door ons aangetoonde overlevingskansen vergelijkbaar met andere studies die goede resultaten beschrijven van solide botgrafts bij patiënten met heupdysplasie (tabel 4 in hoofdstuk 6).

Het behandelprotocol voor patiënten met heupdysplasie zoals dat gevolgd wordt in Edinburgh betreft, evenals de botimpactie techniek, een biologisch aantrekkelijke benadering aangezien botdefecten hersteld worden met lichaamseigen materiaal. Hoewel sommige auteurs het gebruik van solide botgrafts bij heupdysplasie afzagen is wel degelijk aangetoond dat herstel met deze botgrafts van nut is voor toekomstige ingreepen. De overleving van de reconstructie wordt mede bepaald door de wijze van prepareren en aanbrengen van de botgraft. De wijze waarop de techniek in Edinburgh wordt toegepast is in grote lijnen hetzelfde gebleven. Er wordt een wig uit de heupkop genomen welke ter hoogte van het acetabulaire superolaterale defect wordt gefixeerd met twee schroeven (figuur 1 in hoofdstuk 6). Hierbij sluit de
bolle kant van de graft goed aan op het holle defect van het acetabulum. Na goede compressie van de graft op het bekken kan na voorbereiding van het acetabulum op standaard wijze een gecementeerde cup geplaatst worden.

In tegenstelling tot eerdere studies hebben wij goede resultaten gevonden van deze lichaamseigen solide botgrafts in combinatie met gecementeerde heupprothesen. Ook na een gemiddelde follow-up van meer dan 10 jaar blijkt deze techniek een duurzame oplossing voor patiënten met ernstige heupdysplasie.

5. Wat zijn de radiologische en klinische resultaten van ongecementeerde heupprothesen bij patiënten jonger dan 50 jaar?

Tegenwoordig is het gebruik van een ongecementeerde heupprothese de meest gebruikte oplossing voor een jonge patiënt met artrrose van de heup. In hoofdstuk 7 worden de klinische en radiologische resultaten van een ongecementeerde heupprothese beschreven. Wij evaluerden 73 Zweymüller totale heupprothesen met een titanium Schroefcup en een polyethylene insert in 67 patiënten. De gemiddelde leeftijd ten tijde van operatie was 43 (23 - 49) jaar. Na een follow-up van gemiddeld 17,5 (15 – 21) jaar bleek dat 3 patiënten (met 3 heupprothesen) waren overleden en dat 7 patiënten (met 8 heupprothesen) niet meer te traceren waren. Drie heupprothesen werden gereviseerd ten gevolge van septische loslating, 3 cups vanwege aseptische loslating en 1 prothese vanwege een periprosthetische fractuur. Van de patiënten beschikbaar voor evaluatie was de gemiddelde Harris Hip Score 90 (52-100) en de gemiddelde Oxford score 22 (14 - 43). De overlevingskans met als eindpunt revisie voor alle redenen was 89% en met als eindpunt revisie voor aseptische loslating 94% na 17 jaar. Er werd een worstcase scenario voor de cup geanalyseerd waarin radiologische loslatingen werden opgenomen en waarin patiënten zonder een recente röntgenfoto werden beschouwd als gefaald constructie. In dat scenario was de overleving 84% na 17 jaar. Voor zover er resultaten gerapporteerd zijn over andere ongecementeerde heupprothesen bij jonge patiënten zijn de door ons gevonden overlevingskansen gunstig. Een landelijk onderzoek in Finland naar totale heupprothese bij patiënten jonger dan 55 jaar laat namelijk zien dat de overlevingskans van ongecementeerde cups onbevredigend laag is als revisie vanwege een versleten insert wordt.
Summary in Dutch/Nederlandse samenvatting

meegenomen. Er zijn veel verschillende typen ongecementeerde cups beschikbaar met uiteenlopende resultaten en overlevingskansen en in hoofdstuk 7 hebben we de resultaten beschreven van slechts één type. In deze reeks van jonge patiënten werden echter hoge overlevingskansen gevonden van de Zweymüller totale heupprothese met een titanium schroefcup na 17 jaar. Het blijkt dat een poreus oppervlak van de prothese en benige ingroei essentieel zijn voor goede stabiliteit en langdurige fixatie van dit model heupprothese.

6. Zijn de keuzes voor heupimplantaten voor jonge patiënten in Nederland gebaseerd op bewijs in de huidige literatuur?

De beschikbare literatuur werd beoordeeld op dit onderwerp om de optimale behandeling te bepalen en de resultaten van dit onderzoek zijn weergegeven in hoofdstuk 8. Medline en Pubmed werden gebruikt om alle beschikbare studies te vinden die resultaten van gecementeerde en ongecementeerde totale heupprothesen bij patiënten jonger dan 50 jaar meldden in de periode van 1966 tot 2009. Referentielijsten van de gevonden artikelen werden bekeken om overige relevante literatuur te vinden. Daarnaast werden gegevens uit het Zweedse heupregister geanalyseerd. Er werden 109 relevante artikelen gevonden waarvan 37 een gemiddelde follow-up van langer dan 10 jaar meldden. Slechts twee studies over ongecementeerde heupprothesen voldoen aan de criteria van overleving van minimaal 90% na 10 jaar follow-up, zoals gepubliceerd door het National Institute for Clinical Excellence (NICE). Daarentegen voldoen meerdere studies over gecementeerde heupimplantaten aan dit criterium (tabel 1 in hoofdstuk 8).

Vervanging van een versleten insert bij een ongecementeerde heupprothese wordt niet altijd gerapporteerd als een revisie en dit kan vergelijking van overlevingscijfers tussen studies moeilijk maken. Ook dient men bij interpretatie van overlevingscijfers van Nationale registers voorzichtig te zijn aangezien data van verschillende typen heupprothesen worden verzameld. Een slechter presterende ongecementeerde prothese kan de uitkomst van goed presterende prothesen overschaduwen. De conclusie van dit hoofdstuk is dat op dit moment de hoogste overlevingskansen worden gezien bij gecementeerde heupimplantaten en dat de huidige trend om ongecementeerde implantaten te gebruiken bij jonge patiënten niet wordt ondersteund door beschikbare literatuur.
7. Wat is op lange termijn de meest kosteneffectieve behandeling van een jonge patiënt met artrose van de heup?

Inmiddels is het bewezen dat het plaatsen van een totale heupprothese een zeer kosteneffectieve procedure is bij oudere patiënten en dat de kwaliteit van leven sterk verbeterd. Bij jonge patiënten zijn de resultaten echter minder gunstig. Juist bij deze groep is het raadzaam om kosten van revisieoperaties mee te nemen in de berekening van de kosten op de langere termijn. In dit kader hebben wij een kosteneffectiviteitstudie verricht waarbij twee behandelingstrategieën worden vergeleken voor de jonge patiënt met artrose van de heup en een acetabulair defect. We hebben een beslissingsmodel ontworpen om de kosteneffectiviteit te bepalen van een gecementeerde cup met acetabulaire opbouw versus een ongecementeerde cup, in termen van kosten per quality-adjusted life year (QALY). Het model en de resultaten hiervan worden gepresenteerd in hoofdstuk 9. Gegevens over kosten en overlevingscijfers werden verzameld in het Radboud University Medical Centre en het Noorse Heup Register. Meervoudige gevoeligheidsanalyse werd gebruikt om de bijdrage van de diverse variabelen op de uitkomst van het model te beoordelen.

Uit deze analyse blijkt dat het plaatsen van een gecementeerde cup met acetabulaire opbouw kosteneffectiever is dan het plaatsen van een ongecementeerde cup, in termen van kosten per QALY. Ook in een scenario met gelijke overlevingskansen van gecementeerde en ongecementeerde cups wordt nog steeds een effect winst van de gecementeerde cup gezien maar tegen hogere kosten.

Analyse toont dat een groot deel van de uitkomst van het model wordt bepaald door kosten van de prothese. Een recente studie in Groot-Brittannië laat zien dat een mogelijke kostenbesparing voor de National Health Service (NHS) van meer dan £18 miljoen per jaar zou kunnen worden gerealiseerd wanneer gecementeerde in plaats van ongecementeerde heupprothesen zouden worden gebruikt in Engeland en Wales.

Opmerkelijk genoeg verschillen de gebruikte heupimplantaten sterk tussen de diverse ziekenhuizen in Nederland. Criteria voor de keuze van implantaten zouden transparanter moeten worden aangezien de kosten van deze implantaten een belangrijke rol spelen in de kosteneffectiviteit. Naast de kosten is uiteraard de effectiviteit of overleving van een heupprothese van belang. Bij jonge patiënten is vaak een revisieoperatie noodzakelijk op termijn en dit brengt hogere kosten met zich
mee. Om hier rekening mee te houden zijn drie revisies met bijbehorende kosten opgenomen in het model. Daarnaast is in het model verwerkt dat de tevredenheid en functionaliteit van patiënten na een revisieoperatie vaak minder is. In deze studie is een gecementeerde cup met acetabulaire opbouw een kosteneffectievere methode dan een ongecementeerde cup voor de jonge patiënt met artrose van de heup. Dit model zou een nuttig instrument kunnen zijn voor ziekenhuizen, beleidsmakers en orthopedisch chirurgen om meer inzicht te krijgen in kosteneffectiviteit van implantaten en daarmee hun keuze voor een heupimplantaat te onderbouwen.

Conclusie

Er zijn verschillende opties voor de behandeling van de jonge patiënt met artrose van de heup, echter welke de meest duurzame oplossing is blijft controversieel. Dit proefschrift toont aan dat goede lange termijn resultaten kunnen worden bereikt met zowel gecementeerde als ongecementeerde heupimplantaten. Op basis van de huidige literatuur dient men echter te concluderen dat het merendeel van de beschikbare studies die een hoge overleving van heupprothesen laten zien zijn gebaseerd op gecementeerde heupimplantaten. Hoewel de resultaten van onze studie betreffende een type ongecementeerde heupprothese goed zijn hebben we nog geen informatie over de resultaten van revisieoperaties van deze prothesen. De discussie of gecementeerde of ongecementeerde heupimplantaten de meest duurzame oplossing voor jonge patiënten zijn wordt ook vertroebeld doordat resultaten van verschillende modellen heupprothesen worden verzameld en als groep worden geëvalueerd. Als we onze keuze baseren op de beschikbare literatuur dan moeten we concluderen dat in het algemeen deze in het voordeel is van gecementeerde implantaten bij jonge patiënten. Wellicht dat dit beeld na verloop van tijd gaat veranderen.

In Nederland worden momenteel veel verschillende soorten heupprothesen gebruikt bij jonge patiënten. Recentelijk heeft de Nederlandse Orthopaedische Vereniging een lijst van goedgekeurde ontwerpen gepubliceerd*, gerangschikt volgens de overlevingskansen bekend uit de internationale registers en beschikbare literatuur. Wij willen pleiten voor een verdere standaardisatie van goed presterende heupimplantaten voor Nederlandse ziekenhuizen, in het bijzonder voor jonge

*beschikbaar online op http://www.orthopeden.org/uploads/ZA/rV/ZA/rVe9kSoX79e0P8yfW4w/Advies-NOV-bestuur-over-het-gebruik-van-primaire-heupprothesen-10-feb-2013.pdf
patiënten. Daarnaast zou concentratie van de behandeling van “complexe heupaandoeningen” door gespecialiseerde chirurgen bevorderlijk kunnen zijn om meer expertise op dit gebied op te kunnen bouwen. Dit zou de orthopedische zorg voor jonge patiënten met artrose van de heup ten goede kunnen komen.

Met betrekking tot acetabulaire defecten bij jonge patiënten gaat de voorkeur uit naar biologische reconstructie. Dit lijkt de meest duurzame optie aangezien deze patiënten waarschijnlijk geconfronteerd gaan worden met een of meerdere revisieoperaties. Reconstructie kan gebeuren met behulp van solide botgrafts en/of geïmpacteerde botsnippers, in combinatie met een gecementeerde cup. Op basis van kosteneffectiviteit gaat de voorkeur uit naar reconstructie van een acetabulair defect door middel van geïmpacteerde botsnippers en een gecementeerde cup.

We hopen dat de uitkomst van dit proefschrift een rol gaat spelen in de besluitvorming van ziekenhuizen, beleidsmakers en orthopedisch chirurgen in het kiezen van de meest duurzame behandeling van de jonge patiënt met artrose van de heup.
Chapter 12

Acknowledgements/Dankwoord

Publications

Curriculum Vitae
Acknowlegements/Dankwoord

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Publications/Publicaties


Vincent is getrouwd met Rianne Busch-Gaffert en zij hebben een dochter Fréderique.

The young osteoarthritic hip:
Clinical outcome of total hip arthroplasty and a cost - effectiveness analysis

Artrose van de heup is een veelvoorkomend probleem en kan mensen behoorlijk beperken in hun dagelijkse activiteiten. Ook bij jonge mensen komt heupartrrose voor, maar dan is er vaak een onderliggende oorzaak zoals reuma of heupdysplasie. Als pijnstilling niet meer helpt kan een heupprothese uitkomst bieden. Er zijn echter veel verschillende soorten prothesen en technieken beschikbaar. Maar wat is de beste methode op lange termijn? En wat te doen als er sprake is van botverlies van de heupkom? Wat is de meest kosteneffectieve methode op lange termijn?

Dit proefschrift beschrijft de klinische resultaten van diverse technieken om jonge patiënten met heupartrrose te behandelen en hoe om te gaan met botverlies van de heupkom.