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Atraumatic Restorative Treatment  
and  
oral health in Upper Egypt

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Atraumatic Restorative Treatment and oral health in Upper Egypt

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# Atraumatic Restorative Treatment and oral health in Upper Egypt

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# Atraumatic Restorative Treatment and oral health in Upper Egypt

Doctoral Thesis

to obtain the degree of doctor  
from Radboud University Nijmegen  
on the authority of the Rector Magnificus, prof. dr. S.C.J.J. Kortmann,  
according to the decision of the Council of Deans  
to be defended in public on Wednesday, 19 December, 2012  
at 14.30 hours

by

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## **CHAPTER 1**

### **Introduction**

## **Abstract**

Chapter 1 provides background information on the oral health system in Egypt, and oral health status of Egyptian inhabitants. This information is essential to full understanding of the context of this PhD research. Relevant information about the study area, Upper Egypt, is presented. The concepts of ART are explained. The chapter concludes with a presentation of the rationale and aims of the research.

## **Demographic situation**

Bordered by the Red Sea to the east, by the Mediterranean Sea to the north, by Libya to the west and by Sudan to the south, Egypt is located in the North-East corner of Africa. Covering a total area of 1,001,450 km<sup>2</sup>, it is divided administratively into 29 governorates. The country is largely synonymous with the 1550km-long Nile River. Cairo, the capital, is located south of the point where the Nile diverts into the Nile Delta area. This part of the country consists of 8 governorates. From the south of Cairo to Aswan, in Upper Egypt, seven governorates are found. The other governorates are located in Sinai, the eastern and western desert and along the Suez Canal (1, 2).

The total population of Egypt in 2011 has been estimated to be 82.1 million and the country's growth rate is 1.96 % (2011 est.). At least 45% of the population live in urban areas. On the basis of the assumption that many Egyptian "villages" have grown into small-sized towns, some sources even estimate that 60% of the Egyptian population live in urban areas (3). The most densely populated areas are found in the big cities, Cairo, Alexandria, Giza, and along the banks of the Nile and the Suez Canal. Population density has reached 1,540 persons per km<sup>2</sup> in those areas, whereas the population density for the country is estimated to be 113 persons per km<sup>2</sup>. There are small communities spread throughout the desert regions. These are clustered around oases and historic trade and transportation routes (1).

## **Economy**

Egypt belongs to the group of low- to middle-income countries. The average per capita income in 2010 was \$6,200. Egypt's economic spectrum covers a great diversity and includes agriculture and industries like those related to textiles, food processing, chemicals, pharmaceuticals, hydrocarbons, construction, cement, metals and tourism, in addition to electricity, oil and natural gas exports.

In the past twenty years Egypt has experienced a stable economy, enjoying continuous growth averaging 4%–5%. During the various stages of this development, the public and private sectors played roles varying in relative importance. Most of Egyptian economic activity takes place in north-eastern Egypt, the Nile Delta and along the Nile Valley. Despite the relatively high levels of economic growth, living conditions for the average Egyptian remain poor. About 20% of the population lives below the poverty line (2005 est.). Currently the two basic problems that Egypt is facing are the increasing population and high level of unemployment. Since January 2011 the Egyptian economy has faced many difficulties resulting from the political changes all over the country (1, 2).

## **Health care system in Egypt**

Egypt's health care status is poor in comparison to the level of its national income and that of countries with a similar national income (4). The total health care spending in 1994/95 was estimated to be equivalent to 3.7 % of GDP (5) and progressively increased to a mere 4.7% of GDP in 2010 (6).

The health care system in Egypt is complex and pluralistic, with several public health programs and considerable private sector provision. The major provider of care is the Ministry of Health (MOH), which runs a nationwide system of health services, ranging from outpatient clinics to large urban-based hospitals providing a mix of inpatient and outpatient care. These services are administered on a decentralized basis, with most service facilities run by the 29 governorates, which are the major sub-national governmental authorities in Egypt. The governorates are funded through a decentralized health budget provided by the Ministry of Finance. MOH services are subsidized, and provided largely free to all citizens.

The second major public financier and provider of healthcare is the Health Insurance Organization (HIO), which was established in 1964 with the intention of eventually covering the whole population. The HIO is a compulsory social insurance agency,

which levies mandatory payroll contributions from all formal sector workers, their employers and public pensioners. However, as with similar programs in other low- to lower-middle-income countries, universal coverage has remained elusive, and coverage has remained restricted to the small urban formal sector. Coverage applies only to the enrolled worker, and does not extend to dependents. Small co-payments are required from some workers, but these are quite small in relation to benefits provided.

Although, HIO operates as an insurance agency, in practice its annual expenditures are greater than its income from premiums. Consequently, it receives ad hoc subsidies from the Egyptian government to enable it to pay unpaid creditors and occasionally, for capital expenditures. HIO can thus be regarded as a funding mechanism combining features of both social insurance and general revenue financing.

A separate HIO program introduced in 1993, the Student Medical Insurance Program (SMIP), provides insurance coverage to over 7 million students. SMIP is financed by a mix of individual premiums paid by enrolled students, a specially earmarked cigarette tax and a contribution from general revenues. Only registered students are eligible to enrol. Children who are not going to school, typically those from the poorest families, are not eligible. SMIP combines elements of social insurance and general revenue financing but it can be characterized as a general revenue funded program with a modest insurance element.

The MOH recently initiated a special preventive, primary and curative program at family health units, centers and district hospitals, for preschool children and pregnant and nursing mothers (7). The Ministry of Health also runs a small number of specialized national teaching hospitals which provide largely free care. The Education Ministry, through its budget, supports twenty-one university hospitals. These provide a higher quality of care than MOH facilities do, and receive higher government subsidies per unit of service. The university hospitals are linked to the universities but

they are open to all patients. They charge patients user fees although they remain largely subsidized. Other ministries, including Transport and the Armed Forces, run their own facilities for staff and their dependants and, in some cases, these facilities are also available for use by the general public.

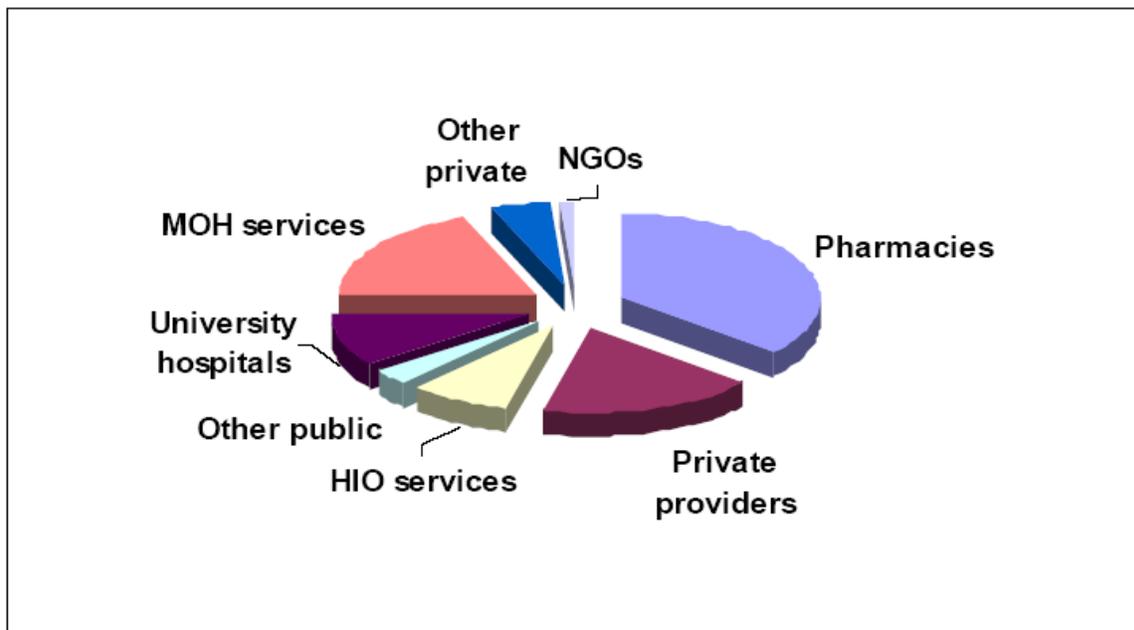
The third sector that provides healthcare includes private organizations such as private insurance companies, unions, professional organizations, and non-profit non-governmental organizations (NGOs) (3). While public provision dominates their inpatient care services, Egyptians make considerable use of private ambulatory services which comprise the fourth healthcare provision sector in Egypt. These are mainly available in private clinics, but include pharmacies and non-governmental clinic services. Private clinics are staffed for the most part by government doctors, who are allowed to work privately in their off-duty hours. There is a small private hospital sector, which is concentrated in the capital cities and metropolitan areas. The private services are all funded by private out-of-pocket spending, supplemented by a very small amount of private insurance. Households make substantial use of pharmacies for obtaining medication and, in some cases, treatment advice.

The Government of Egypt has recognized that the MOH had identified fragmentation in the delivery of health services, excessive reliance on specialist care and the low quality of the primary care service. That is why Egypt embarked on a major restructuring of the health sector and the Egyptian Health Sector Reform Program (HSRP) was officially launched in 1997 (8).

## Oral health services

The oral health service is mainly provided through (Figure 1.1):

1. The MOH, hospitals, urban centers and rural health clinics;
2. University hospitals, teaching hospitals and medical institutions;
3. Ministry hospitals, including those of the Transport Department, the police and the armed forces;
4. HIO hospitals, medical centers and clinics;
5. Private hospitals, medical centers and dental clinics.



**Figure 1.1:** The Egyptian financial resources covering healthcare provision (4)

Generally the current oral healthcare services in governmental sectors are below standard, except for those offered by university and teaching hospitals and a few private clinics and hospitals. In the private sector, the kind of dental care and services offered vary dramatically and depend mainly on the financial conditions of providers and consumers. People in the privileged socio-economic segment of the population seek treatment from high standard dental clinics and hospitals, where well-trained

qualified dentists deliver quality dental care. However, the middle- and low-socio-economic segments seek treatments from government clinics or modest and poor private dental clinics run by GDP (general dental practitioners) which, in most cases, cannot provide high standard quality treatments (9). The universities and teaching hospital provide a reasonable level of dental care, as most of the providers are specialists or well-trained dentists. In the governmental clinics, most of the treatment provided is extraction, scaling, prescription of medication. A limited number of dental fillings are provided in a few clinics. The low standard of dental care provided through the governmental sectors can be attributed to the factors mentioned in the following sections.

### ***Manpower***

The number of the dentists working in the different health sectors in Egypt is 35,000 (10) and the dentist per 10,000 population ratio is 4.2 (11). Unfortunately there is a maldistribution of dental personnel in Egypt. The majority of dental practices are in the big cities and their focus is on earning high incomes to cover postgraduate studies and/or further dental training (12).

Most of the country's dental schools are located in Cairo and the capital cities of the Nile Delta (Figure 1.2). Only one dental school is situated south of Cairo, in the Elminia governorate. Thus, the dentist/population ratio in the rural areas, where 60% of the Egyptian population lives, is low (13). The MOH has increased the salaries of the dentists there, in an effort to make work in rural areas more attractive but this move has not contribute to improvement of either the dentist/population ratio in the rural areas or the dental services provided there. In general, the salary of public service dentists all over the country is very low, which negatively affects the provision of dental care.

### ***Education and training***

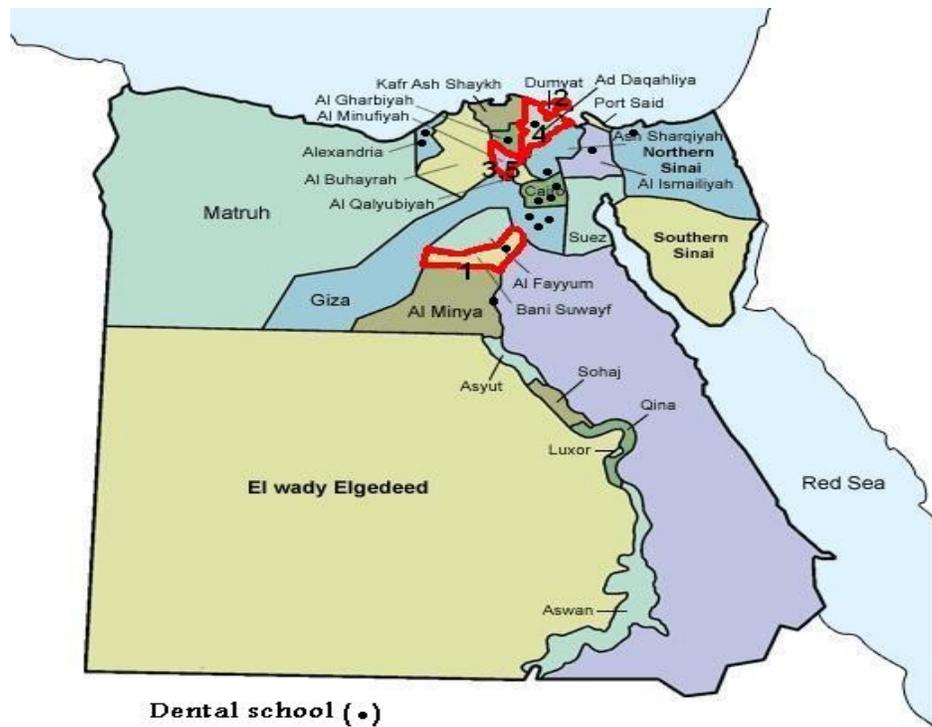
Lack of effective continuing education programs, poor scientific refreshment courses and short-term training programs for GDP work in rural and suburban areas in Egypt

have contributed to poor oral healthcare and, in particular, to low levels of restorative services provided to the rural and suburban population of Egypt.

### ***Stakeholders***

Oral care and dental hygiene is not a major concern for many Egyptians, especially the uneducated middle- and lower-income population. In general, these people are not being educated about the importance of seeking oral health care regularly, solving oral health problems and factors involved in maintaining good oral health (14).

Although the government dental clinics are located in different geographic areas and services provided are free of charge or partly funded, it was observed that the number of patients visiting the dental clinics was very low. The majority of people seek dental treatment only when pain is experienced. Extracting the painful tooth is then the dental treatment mainly provided. The situation is such that the demand for dental care is very low in comparison to the dental needs of the people. With the constant increase in the population, Egypt is facing a huge problem of unmet accumulated dental needs (9).



**Figure 1.2:** Distribution of the dental schools in the different governorates of Egypt.

### ***Dental equipment and materials***

Lack of adequate and efficient maintenance of dental equipment and an inadequate supply of the necessary dental instruments and tools have resulted in very basic and inadequate oral healthcare provision in most governmental clinics. This can be attributed to poor financial resources and lengthy administrative procedures. It is hard to find a government dental clinic that is fully equipped, except for a few clinics in the capital cities. Reasons often cited for this situation include: 'The hand piece is not working'; 'The dental unit needs maintenance', 'No restorative materials, anaesthetics or light curing devices are available' or 'There are no hand instruments'.

### ***Management***

Lack of a specified effective training programme for the managers in MOH hospitals and clinics contributes to poor management and ineffective use of all the available resources and manpower.

All the above-mentioned reasons call for a fundamental structural change in the medical, and certainly in the dental, services of the country. The population is not being served well at the moment. Which aspect to tackle first is not dealt with in this PhD thesis. Nevertheless, a possible approach towards starting to change the situation will be discussed/ suggested.

## **Dental caries in Egypt**

It is well known that poor oral health can negatively affect the general health, productivity and quality of life of any population. Poor oral health creates major health problems and reversing the situation requires a lot of effort and money, especially in developing countries (15, 16). Dental caries and its sequels are the main causes of oral pain, disability and tooth loss. The most common cause of tooth loss in low- and middle-income countries is dental caries (17, 18). Egypt, considered being one of the low- to middle-income countries, suffers from poor oral health in its population, especially in rural areas and Upper Egypt.

Very few epidemiological surveys are carried out in the country. However, a few have been conducted. A resume of the findings of these surveys follows.

In the early seventies in Alexandria the mean DMFT score at ages 10-19 years was found to be 4.5, and it was 11.9 in the age group of 50-60 years. The highest percentage of decayed teeth was found amongst the 10-19 year-olds, while the highest percentage of missing teeth was found in the age group of 50-60 years. The filling component was negligible in all age groups (19).

A decade later in Alexandria the mean DMFT scores for 15-, 16- and 17-year-old students were 4.3, 4.8 and 5.2, respectively (20). In the same decade, in rural areas of the Dakahlia governorate the mean DMFT scores in the 8-9, 13-14 and 35-44 year-old age groups were 2.0, 5.9 and 10.0, respectively. Untreated cavitated teeth constituted 80%, 85% and 53% of the DMFT scores and no fillings were recorded amongst the 8-9- and 13-14-year-old children (21). In the Giza governorate, caries

prevalence was 83.8% for patients aged 5-80 years. The prevalence and severity of dental caries increased with increases in age, especially amongst females (22). In the North Sinai and Red Sea governorate the mean DMFT scores were 3.4 and 9.3 for the 8-12 and 20–40 year-old age groups, respectively. It was reported that caries experience was much higher in rural than in urban areas (23). In the Algharbia governorate the mean DMFT score was 2.9 for 13-year-old children and it was 4.3 at age 15 years. The caries prevalence was 72.3% and 82.3% at ages 13 and 15 years (24). In the Behira Governorate the mean DMFT scores were 1.4, 2.6 and 4.5 for the age groups 8-12, 13-15 and 16-18 years, respectively (25).

Increased caries severity in young children to 30-year-old adults was reported in three villages in the Menofia Province. The study also found that only one out of 176 cavitated carious teeth was restored. This clearly indicates an almost complete absence of restorative care in those rural areas (26). In Cairo it was found that students from low socio-economic areas had higher DMFT (8.8) scores than peers from middle (3.6) and higher (1.4) socio-economic areas. This showed the disparity existing in health and healthcare between Egyptians from different socio-economic backgrounds. It calls for an extensive program of preventive, promotion and restorative care (27).

In 2007, a caries epidemiological survey was carried out amongst adolescents who attended two secondary schools in Cairo. These schools had a health unit in which a dental clinic was situated operated by one dentist. The prevalence of dental caries, based on dentine cavities, was 38% and the mean DMFT score was 0.8. The prevalence of teeth filled and extracted was low. The survey concluded that most of the cavitated lesions were found untreated despite the presence of a dental clinic and a dentist (28).

In the Upper Egypt governorate, information about oral health was found to be scarce because of the limited access to the community and the low number of dentists

employed. The conclusion was that the dental service provision in this part of Egypt urgently needed to be improved (29).

These studies indicate that people in rural areas of Egypt suffer a high burden of untreated dental caries and its sequelae in the absence of appropriate dental care, in terms of dental personnel and dental facilities.

### **Towards a rational option for managing the problem**

Recently the Egyptian Ministry of Higher Education and Research, together with the Ministry of Health, realized the importance and urgent need for applied clinical research, especially in the medical and dental field, in order to solve many of the present health problems. They also realized that the structure and content of most medical care systems and the content of medical and dental curricula still follow the traditional way of treating diseases and decided that these aspects urgently need to be updated. The Ministry of Higher Education has started updating the contents of the curricula of all faculties. It has emphasized that medical and dental curricula must be based on state-of-the-art knowledge and future perspectives (30). At the same time, quality assurance units were set up to follow the procedures and ensure the quality of the outcomes.

The curriculum of the Dental School in Minia has undergone changes and has been adjusted to meet the challenges of the modern way of teaching university students (30). With respect to appropriate restorative care, the curriculum contains a model related to the Atraumatic Restorative Treatment (ART) approach, as this preventive and restorative caries management approach was thought to be suitable for dealing with the unmet treatment needs of the population.

#### ***ART world wide***

ART was originally developed to treat carious teeth in deprived and underserved populations (31). It is based on removing the carious parts of the tooth with hand

instruments and then restoring the cavity and sealing adjacent pits and fissures with a high-viscosity glass-ionomer. ART is one of the minimal intervention approaches used to control dental caries. It also includes a caries-preventive approach which involves the sealing of all pits and fissures adjacent to the cavity and sealing caries-prone pits and fissures in non-cavitated teeth.

ART has been used to treat primary and permanent teeth in several countries and has been shown to provide a high survival rate (32, 33). In comparison to conventional amalgam restoration, the high-viscosity glass ionomer ART restorations have survived longer in the permanent teeth of young children (34). ART seems to cause less pain than conventional treatment and leads to lower patient anxiety (35).

Many countries, especially developing countries where dental equipment and trained dentists are not easily available, have adopted the ART approach (36, 37). Developed countries like the United Kingdom, Netherlands and USA have adopted the ART for treating tooth cavities in young children, elderly people and physically and mentally handicapped people (38-40).

Another important aspect of ART relates to its cost-effectiveness. In Panama, Ecuador and Uruguay, the cost of ART restorations was nearly half that of traditional Amalgam restorations after 2 years (41). Similar results were reported by Mickenautsch et al (2002), who stated that the annual capital cost of the ART approach is approximately 50% less than that of both amalgam and resin-composite restorative procedures in private practice (42).

Not all dentine cavities can be treated using ART. A study amongst 12- to 14-year-old Egyptians showed that the majority of non-pulpal involved cavities could be restored using ART and that many very small carious lesions could be sealed using ART (28). This seems to indicate that the ART approach, in principle, is very suitable for use in Egypt.

### ***ART in Egypt***

The situation analysis regarding the provision of dental care in Egypt clearly showed that the currently installed preventive and restorative care has failed to serve the majority of Egyptians. If this situation is to improve, a drastic change in the current traditional oral care system needs to take place.

A decade ago, at the Dental School of Minia, the first ART study in Egypt was carried out (43). This one-year study was followed by two short ART courses that took place in Alexandria in 2006 and in Cairo in 2007. The authorities of Minia Dental School thought that the introduction of ART could be beneficial in changing the currently unproductive public oral healthcare system. The one-year survival rate of ART restorations amongst adolescents was very high. It was the first sign that the introduction of ART into the system might be able to make preventive and restorative care available for many in Egypt. However, this initial good result was not convincing enough for dentists and those in authority. A number of arguments were raised with respect to the quality of ART restorations in the long run and the issue of bacteria left behind in the cavity after cleaning with hand instruments, which were thought to cause the restoration to fail after a while. These and other concerns led to the continuation of the one-year study, whose results are reported in the present PhD thesis.

### ***Rationale for using ART in Egypt***

Studies from low-middle income countries indicated including the ART approach in the basic oral healthcare system was a necessity (36, 37). In Tanzania, the introduction of the ART in dental public health clinics was successful and accepted by the resident dentists. It contributed to an increase in the number of teeth saved from extraction through the provision of restorative care. The study recommended a wider coverage of the ART treatment modality all over Tanzania (36). A study from South Africa recommended that a situation analysis should be carried out regarding the organization and state of dental clinics and the workforce before introducing the ART approach into the public oral health service (44). Limiting factors that might hinder the application of ART in the public health services included: high workload, negative

operator opinion, inadequate supply of the dental material and the poor management system of the health authorities.

In Egypt health authorities have thought that the ART approach could be applied by health insurance dentists to scholars at primary and secondary schools and included in the services provided by the health insurance clinics. Applying ART in the schools rather than waiting for scholars to seek dental treatment, which in most cases results in extraction of painful teeth, is considered an appropriate early intervention for saving carious teeth. In a similar way, the ART approach could be applied in the clinics run by the Ministry of Health in rural and deprived areas in Upper Egypt. This could provide a good opportunity to increase the percentage of restored teeth and decrease the percentage of extracted teeth and thus in part contribute to the improvement of the oral health of the population in Upper Egypt. However, Egyptian dentists have expressed concern about the basics of the ART concept and the suitability of using high-viscosity glass-ionomer in the posterior teeth. These potential barriers regarding the implementation of the ART in Egypt have to be addressed, and are discussed in this thesis.

## **Chlorhexidine Disinfection and ART**

Because ART depends solely on the use of hand instruments for removal of carious tooth tissue, dentists in Egypt have expressed worries that incomplete removal of infected dentine will cause the development of secondary caries. There are two concepts that deal with the issue of residual infected dentine and the remaining bacteria. The first is that residual carious dentine will not progress if the cavity is properly sealed with an adhesive restoration (45-48). The second concept is that the remaining bacteria will cause secondary caries to occur and therefore, total removal of all affected and infected dentine is recommended (49).

The literature has come up with two plausible solutions to this issue. In the first one direct application into the cavity, of an antibacterial agent such as a chlorhexidine

solution, is followed by the restorative procedure (50-53). The second approach concerns the incorporation of chlorhexidine into glass-ionomer (54). Chlorhexidine-containing glass-ionomer has been found to inhibit the bacteria associated with dental caries in vitro (55, 56) and in vivo (57). However, long-term clinical studies are needed to test the efficacy of this mix. There is also a controversy about whether chlorhexidine solution is really necessary as part of the ART restoration procedure.

In response to these perceptions within the country's dental profession, which could inhibit the introduction of the ART approach on a wider scale, it was necessary to study the effect of chlorhexidine solution on the survival of the ART restoration.

### **Criteria for assessing the quality of ART restorations**

During the first major ART study in Thailand, in the early 1990s, special criteria were developed for assessing the quality of ART restorations (58). These criteria were later modified, as some of the characteristics of the glass-ionomer used at that time, like severe wear, were infrequently observed in the Thailand-study. Most studies that have reported the survival of ART restorations have used the original and the modified ART criteria (59).

Mjör and Gordan reported that USPHS criteria are the only criteria internationally accepted for direct clinical evaluation (60). Holmgren et al (61) and Lo et al, (62) applied both the ART and the USPHS restoration criteria to the same ART restorations in permanent and deciduous teeth. They reported no significance differences in survival outcomes of ART restorations between the two sets of criteria (61, 62). Lo et al, (62) assumed that the ART criteria were more stringent than the USPHS criteria and that using the latter set of criteria might lead to higher success rates for any types of restoration.

In order to overcome the limited sensitivity of the USPHS and to accommodate the continually evolving modifications in the operative approaches and techniques, a new

set of criteria was developed: the FDI restoration criteria (63). It allows for aesthetic evaluation and functional and biological assessment of the restorative materials' performance. It also focuses on clarification of the failures in details. As the FDI restoration criteria may become the future standard, it was thought necessary to discover the extent to which this new set of criteria differ in practice from the modified ART restoration criteria regarding the survival of the ART restorations.

## **Discomfort with ART**

Another characteristic of ART that could aid in its acceptance by the dental profession and policy makers of Egypt, was the expressed lower levels of dental anxiety and pain experienced when undergoing a restorative procedure with ART in comparison to those experienced during traditional procedures (64-66). The difference in dental anxiety is ascribed to the absence of rotary equipment and the rare need to use local anaesthesia when applying ART.

Discomfort or sensitivity may also result from stimuli during the dental treatment (35). Increasing the cavity width or depth will result in exposing more dentinal tubules to the oral environment. It consequently increases the possibilities of irritation or trauma to the odontoblasts, which may lead pain or discomfort. It is known that the cavity size after the ART procedure is smaller than it would be after the traditional cavity cleaning approach (67, 68). Therefore, one aim of this PhD thesis was to assess the level of sensitivity experienced during cavity preparation with ART, according to size and depth of the cavity.

## **Objectives of the PhD study**

These were:

1. To assess general common oral care delivered by dental practitioners in Upper Egypt, and to assess their opinions regarding the suitability of preventive and restorative treatment in relation to various stages of dental caries in a highly carious population;
2. To estimate the survival rate of ART restorations with and without cavity disinfection after 5 years;
3. To assess the difference in survival percentages of ART restorations, using selected FDI and modified ART criteria after 1 and 5 years;
4. To assess the level of acceptance and discomfort experienced by secondary school students when undergoing atraumatic restorative treatment (ART) restoration;
5. To evaluate the effect of the introduction of the ART approach into public and private oral clinics in Upper Egypt and to assess dentists' perceived barriers.

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## **Chapter 2**

### **Clinical strategies for managing dental caries in Egypt: opinions of general dental practitioners**

This chapter is based on:

Farag A, van der Sanden WJM, Mulder J, Creugers NHJ, Frencken JE. Clinical strategies for managing dental caries in Egypt: opinions of general dental practitioners. Submitted, 2012.

## Abstract

**Aim:** To assess the opinions of GDPs in Upper Egypt regarding preventive and restorative treatments for various stages of carious lesion development and to obtain information about clinical procedures in private practices and public services..

**Methods:** A 42-item questionnaire was constructed for obtaining the GDP's opinions, while practice information was obtained by using a clinical record form covering a 1 month period. Factor analyses (with Varimax rotation) were conducted to identify scales (clusters) of variables. Logistic regression analyses, with continuing professional development as dependent variable, were conducted to test for the effect of single and scaled factors regarding inclinations to perform preventive or restorative treatments.

**Results:** All 70 participants returned the questionnaire. The clinical record forms registering clinical activities in government and private dental practice were returned by 59 (84%) and 25 (36%) participants, respectively. Three scale factors, i.e., treatment strategies, were identified as: 'operative-minded dentists' (who make >10 amalgam and resin composite restorations); 'problem solvers' (who have >10 years of experience, see >60 patients and make >10 temporary restorations per week); and 'thinkers' (who spend >50 hours / year on continuing professional development but also make >10 restorations). Logistic regression analyses found only one statistically significant relationship ( $p=0.03$ ): 'operative-minded dentists' indicated provision of significantly less caries-preventive measures. Most patient visits were pain-induced, and main treatment provided was removal of teeth.

**Conclusion:** It was concluded that most GDPs in Upper Egypt have an operative-minded treatment philosophy, and spend less time on preventive measures. Treatment provided most frequently is removal of teeth. In cases involving a plastic restoration, amalgam is the primary restoration material.

## Introduction

The latest national oral health survey in Egypt was carried out in 1990 and revealed an alarming oral health situation (1). Since then, only one epidemiological survey has been conducted in the province of Upper Egypt (2). This survey showed a low level of restorative care and a high level of unmet treatment needs in the child population. The authors recommended urgent improvement of dental services.

The findings of the Upper Egypt-study corroborate well with the results of two surveys related to the effectiveness of the public health service in other regions of Egypt. These two surveys showed that extraction rather than restorative care was the first choice in treating cavitated dentine carious lesions: only 4.5% of these teeth had been treated restoratively (3, 4). Reasons for the low level of (restorative) care had not been investigated. However, there is ample information that the dental equipment in many of the public health service clinics is not functioning because of mechanical failure and absence of spare parts. Such a situation restricts the use of the traditional restorative treatment model and calls for improvement of the state of the equipment or the use of alternative treatment models.

A preventive and restorative care model unrelated to dental equipment is that of the Atraumatic Restorative Treatment (ART) approach which, if introduced, could improve the delivery of oral healthcare services (5).

However, the decision about which treatment should be used is not only related to the availability of dental equipment. Traditionally, treatment decisions in dentistry are mainly based on personal practice observations, personal experiences and intuition. This process results in inaccuracy and inter-professional variation. Nowadays, integration of best available evidence-based information and patient values plays a prominent role in deciding which treatment should be offered (6). Further information about the Egyptian oral health care system is presented in Box 2.1.

Little information is available about caries management strategies used among general dental practitioners (GDPs) in Upper Egypt. Different restorative strategies adopted by GDPs in their dental clinic have been previously studied in various countries using questionnaires (7, 8). The present study aimed to assess the opinions of GDPs in Upper Egypt regarding the indication of preventive and restorative treatments, as well as to assess their choices of restorative dental material, at various stages of the carious process, and to collect the number of dental restorations and extractions performed in private and government clinics.

## **Methods**

The study protocol was approved by Minia University, Faculty of Dentistry, Egypt (ERC/2010/12), and was registered in the Netherlands Trial Register (NTR2719). Willingness of and permission from the health authorities in the Ministry of Health (MOH), Cairo, and the Health Insurance Organization (HIO) were obtained, to allow GDPs to participate in the study. MOH presented a convenience sample of 70 interested GDPs, who agreed to participate in this, to our knowledge, first practice based research study in dental clinics in Upper Egypt.

## **Participants and procedure**

The study was carried out among 70 dentists working in Minia and Asyut governorates respectively, in Upper Egypt, as part of a larger study. Inclusion criteria were: 1) sufficient knowledge of the English language, and; 2) being employed in a government dental clinic, and; 3) written consent for participation in this study. GDPs were initially contacted by MOH, and only those who agreed to participate, were presented to the research team. MOH did not provide any information about the total number of invited GDPs. All GDPs on the list were included in this study. Eventually, the number of participating private clinics was 35 (of 164) in Minia governorate, and 35 (of 195) in Asyut governorate. For governmental dental clinics, these figures were 29 (of 248), and 24 (of 144), respectively.

Box 2.1. General information about Egypt and the health care system.

Egypt belongs to the low- to middle income countries. Egypt's health care status is poor in comparison to the level of its national income. The health care system is complex and pluralistic. The major provider of care is the Ministry of Health (MOH), which runs a nationwide system of health services. MOH services are subsidized, and provided largely free to all citizens. However, due to general long waiting times and insufficient equipment, most people will visit a private clinic. The second major provider is the Health Insurance organization (HIO), which was founded in 1964 with the intention of eventually covering the whole population. However, universal coverage has remained elusive, and restricted to the small urban formal sector.

*Oral health care*

A total of 28,000 dentists are working in the different health sectors. There is a misdistribution of dental providers in Egypt, as the majority of private dental clinics are located in the big cities in Lower Egypt. The dentist/population ratio in the rural areas, where almost 60% of the population lives, is consequently low. Due to the 'upper Egypt phenomena of poorness', only a few dentists feel encouraged to work in this region. Oral care and dental hygiene is still not a major concern for many Egyptians, especially the uneducated middle- and low income population. In general, these people are not being educated about the importance of seeking oral health care regularly, solving oral health problems and factors involved in maintaining oral health. Recent national epidemiological data are not available. A study in Cairo in 2008 found that students from low-socio-economic areas had higher DMFT (8.8) scores than peers from middle (3.6) and higher (1.4) socio-economic areas.

*Information about Minya and Asyut Governorates.*

	El Minya governorate	Asyut governorate
Total area:	32,280 km <sup>2</sup>	25,930 km <sup>2</sup>
Population:	4.2 million	3.5 million
MOH dental clinics (n):	248	144
Private dental clinics (n):	164	195
Frequency GDPs (n):	243	175

## Questionnaire development

A questionnaire seeking information about treatment decision making in relation to several stages of carious lesions was constructed. The final questionnaire comprised 42 items, and was initially assessed for its clarity and appropriateness by a panel of 3 experienced GDPs, and modified according to their comments. Nine questions were

related to personal background, 5 requested clinical data, 1 was related to continuing professional development, 7 sought information about the dentist's intentions to use ART and their experiences with this treatment model, 10 were related to information about type of dental restoration used to treat cavities and its frequency of use during 1 week. The following 8 questions each contained 7 statements seeking GDPs' opinions regarding the indication for a preventive or a restorative treatment in specifically designed stages of a carious lesion. Those stages were: (a) outer, and (b) inner part of enamel; (c) just passed through enamel/dentin junction, obvious spread in the (d) outer third, and (e) outer half (but less than halfway through the pulp) of the dentin (f), with obvious spread in the inner half of the dentin (> half way through the pulp), and (g) inner third (pulp threatening) of the dentin (9).

Participants were asked to indicate their level of agreement with each of the opinions expressed, using the following ordinal scale: strongly agree; agree; disagree, strongly disagree. The questionnaire was concluded with a question about which tooth surface was most frequently decayed, for both the child and the adult population.

## **Evaluation**

### ***Questionnaire***

The initial mail sent included a confidentially coded questionnaire, with an introduction about the research project, and a reply-paid envelope. After 1 and 2 months non-respondents were reminded by telephone to return the questionnaire.

### ***Clinical record form***

All participants (n = 70) were asked to personally fill in a clinical record form in both their private and government clinic, every day, covering a period of one month. Data on patients' gender, age, tooth type, toothache, consent, and type of treatment (prevention, restoration or extraction) were collected. With regard to restorations; Black's cavity classification, tooth surfaces, material used (i.e., amalgam, resin composite, glass ionomer, others), and preparation method (ART, conventional) were recorded.

### ***Statistical analysis***

The second author entered the data in an electronic data base. It was checked by the first author. SAS software version 9.2 (SAS institute, Cary, NC, USA) was used for calculations and statistical analyses. Chi Square tests were used to test the influence of age, and district of residence (Minia or Asyut governorate) on the indication to perform a preventive or restorative treatment. Factor analyses (with Varimax rotation) were conducted to identify scales (clusters) of variables, i.e., treatment strategies. Three scale factors were found: 'operative-minded dentists' (those who make >10 amalgam and >10 resin composite restorations per week), 'problem solvers', (those who have >10 years of experience, see >60 patients and make >10 temporary restorations per week) and 'thinkers' (those who spend many (>50) hours per year on continuing professional development and also make >10 restorations per week).

A reliability analysis of the 'item sum of the identified scales with Cronbach's Alpha' could not be performed because of the low number of variables (n = max 3).

Logistic regression analyses, using the responses to the question about 'continuing professional development' as the dependent variable, were performed to test the effect of single and scaled factors on the indication to perform a preventive or restorative treatment, respectively. For these analyses, responses to the questions concerning the 'indication to perform an operative treatment' were clustered into 2 carious stages, i.e., 'enamel caries', containing superficial and deep enamel caries and; 'dentin caries', containing all 5 earlier mentioned dentin caries stages, respectively.

### **Results**

The questionnaire was returned by all 70 dentists (response rate 100%). A Chi-square test found no statistical relationship between age, or district, and the indication to perform a preventive or restorative treatment, respectively. Clinical record forms for government clinic activities were returned by 59 (84%) of the participants, whereas 25 (36%) GDPs returned the forms related to their private clinics.

### ***General aspects***

Seventy-two percent of the respondents were younger than 30 years, whereas the remaining 38% were between 31-60 years old. Mean years of clinical dental experience was 10 yr. (range 2-34 yrs.). All worked in both government and private clinics.

Participants indicated that they spent on average 96 hours (range 5-600; median = 50) per year in continuing professional development.

On average, they spent 13 hours on clinical restorative treatment activities per week (range 4 to 50 hours; median = 10).

Their workload was, on average, 74 patients per week (range 9 to 300; median = 60), of which 50 (range 3-200; median = 40) visited the clinic for relief from dental pain. Two-thirds of the patients (mean = 51, median = 40) were adults.

Only one statistically significant relationship between the scale factors and statements was found: 'operative-minded dentists' indicated significantly less caries-preventive measures ( $p=0.03$ ).

A total number of 45 (64%) participants had heard of the ART approach and 13 (19%) of participants practiced ART.

### ***Clinical aspects***

The main treatment provided in the governmental clinics was removal of badly decayed teeth (65%). An overview of the different direct plastic restorations made in a private clinic during 1 week is given in Table 2.1. Most restorations (36%) consisted of amalgam, followed by a temporary filling material (28%).

**Table 2.1:** Overview of mean frequency (with range) of direct dental restorations (n =33) placed per week in private clinics (n=25), per restorative material and, in addition for resin-composite or glass-ionomer, mean frequencies of posterior restorations only.

<b>Restorative material</b>	<b>Mean frequency</b>	<b>(range)</b>
Amalgam	12	(1-35)
Resin-composite	8	(1-30)
Posterior restoration	3	(0-18)
Glass-ionomer	4	(0-16)
Posterior restoration	2	(0-11)
Temporary	9	(1-35)

### **Questionnaire**

A total number of 45 (64%) participants had heard of the ART approach and 13 (19%) of participants practiced ART.

Logistic regression found only one statistically significant relationship between the 3 identified scale factors and all statements: ‘operative-minded dentists’ indicated significantly less caries-preventive measures (p=0.03).

Figure 2.1 provides an overview of the indicated treatment related to the various carious stages. Superficial and deep enamel carious lesions were indications for monitoring, preventive and direct (plastic) restorative treatment, whereas most other lesions were indications for direct or indirect (crown) restorative treatment.

In case of carious lesions confined to the enamel (Figure 2.1, carious stages 1a, 1b), a direct restoration was indicated by 60.3 percent. Another 20.3% would make a restoration in case the lesions had just broken the enamel-dentin junction, but without obvious spread in the dentin (Figure 2.1, stage 2). The remaining 19.4% would

restore in case the lesions had obvious spread into the dentin (Figure 1, stadia 3a, 3b).

Of the participants, 4.4% would immediately indicate an indirect restoration (crown) in case the carious lesion was observed without obvious spread in the dentin (Figure 1, stage 1a, 1b, 2). Another 31.4% indicated a crown for treatment of dentin lesions with obvious spread up to the outer half of the dentin (Figure 2.1, stadia 3a, 3b). From the remaining, 42.1% would indicate a crown in case of deep dentin lesions (Figure 2.1, stadia 4a, 4b), whereas the other 22.1% never indicated a crown in case a carious lesion was present.

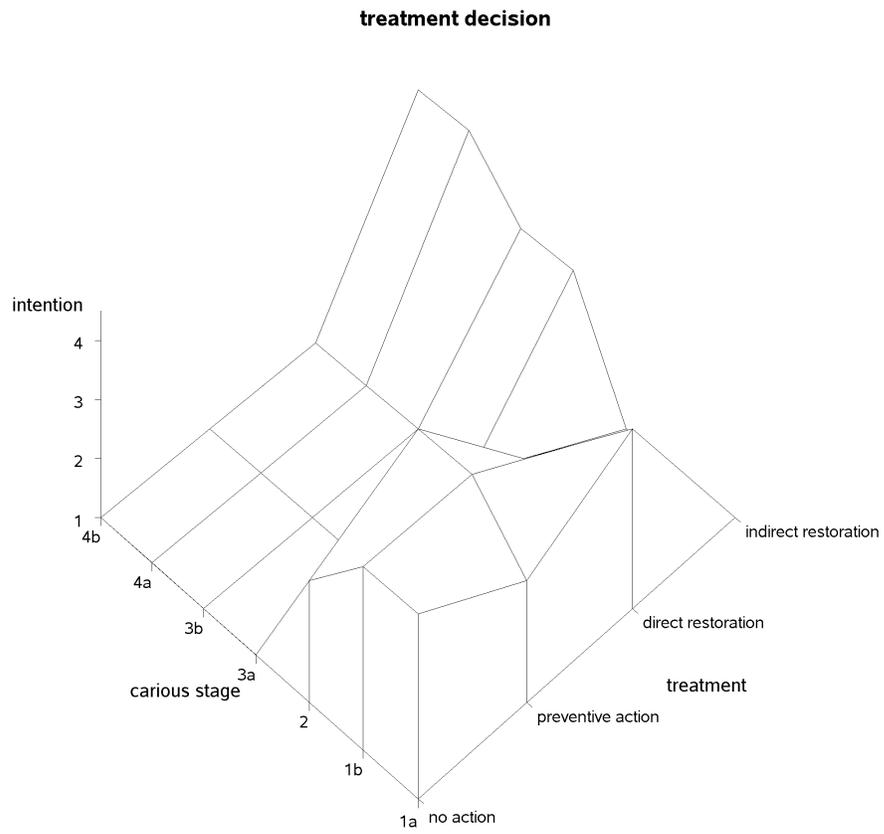
Figure 2.2 gives insight into the plastic material used for direct restorations. Deep dentin cavities were mainly treated with a temporary restoration material. Resin composite material was merely used in cases of enamel lesions, and less in (deep) dentin lesions

Legend for Figure 2.1, and Figure 2.2:

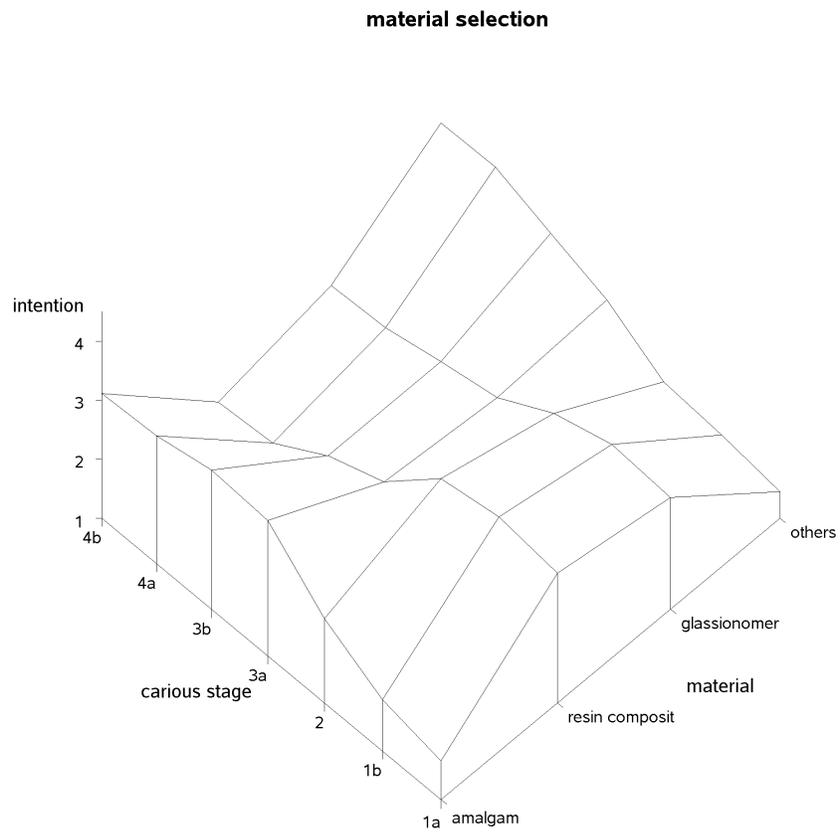
Mean answers (Intention scale 1 = strongly disagree, 2 =disagree, 3 =agree, 4 = strongly agree) plotted on treatment decisions and stages of carious lesion development.

Cariou stage; caries lesion: 1a = up to the inner half of the enamel; 1b = up to , but not beyond the enamel-dentin junction; 2 = with broken enamel-dentin junction, but without obvious spread in the dentin; 3a =; with obvious spread in the outer third of the dentin; 3b = with obvious spread in the outer half of the dentin, (< half way through the pulp); 4a = with obvious spread in the inner half of the dentin (> half way through the pulp); 4b = with obvious spread in the inner two-third of the dentin.

**Figure 2.1**



**Figure 2.2**



## Discussion

The willingness of GDPs to participate in this study was high, as all participants returned the questionnaire. That not every participant returned the clinical record form might be explained by the cultural background (clinical data are considered to be private matter, not to be shared with others). It may also be related to the fact that not all GDPs may use to recording clinical data, especially in their private clinic. Record-keeping appears still to be very limited, as information on subjects like tooth number, filled surfaces etc. was not always registered. Filling in a clinical record form required a change in the pattern of running the practice and this is known to be difficult (10). It is also possible that the political changes in the country, which took place during the course of the study, might have affected the response level.

This study was, to our knowledge, the first practice based research study in Upper Egypt. The results might not be representative for all Egyptian GDPs, and provide insight in what 'early innovators' (10) think and actually perform in their daily clinical practice, and, as such, represent a positive overestimation of current preventive and restorative care. Moreover, possible participants in this study were contacted by MOH, and only those who agreed to participate, were presented to us. As recent general background data about the dentist population in Upper Egypt were not available, a comparison with the characteristics of the study group was not possible. Notwithstanding these limitations, we think that the data generated provide a useful insight into the current beliefs and attitudes of Upper Egyptian GDPs in preventive and restorative dentistry.

Most patient visits were induced by dental pain. This indicates that people only sought dental aid when they were in severe pain. In this area, where 20% of the Egyptians live below the poverty line (11), the person's financial situation is considered a major barrier to visiting a dentist during early stages of dental problems. This so called 'Upper Egypt poverty phenomenon' is still increasing (12). Peoples' behaviour with regard to seeking preventive and restorative care might further be attributed to

cultural or educational background. For example, some people still believe that extraction is better than restoration. Another important issue may be fear of dental treatment, resulting from bad experiences related to previous painful dental treatments (13, 14). Causes of Egyptian patients' attitude regarding dental care are similar to those in other developing countries (15). An alternative and affordable oral healthcare model, such as the ART approach provides, might be suitable for use in Upper Egypt.

All dentists showed an 'operative-intervention-minded' approach with a low level of preventive-mindedness. This may in part be attributed to the manner in which their undergraduate education was organized. Until 2000, the dental curricula followed the traditional way of 'drill and fill'. After that, the higher education enhancement project started ensuring that the training of physicians and dentists would take into account the needs of the health system, including preventive and curative aspects (12, 16). Furthermore, the patient's health concepts and values affect the treatment decision (17).

Most of the Egyptians are unfamiliar with regular dental check-ups. Those who visit a dental clinic are, mostly, in urgent need of help. Preventive approaches are thus less required than operative interventions and this might have affected GDPs' answers. Furthermore, Egyptian people may also be unaware of caries prevention measures, as there is no nationwide oral healthcare preventive program (2, 18, 19). This might indicate that the Egyptian authorities assign a lower priority to oral healthcare than to general healthcare (12).

The questionnaire used in the present study, was based on the one (9) used at the Dental School of Radboud University Nijmegen Medical Centre, whereas other European studies, looking for opinions and attitudes of GDPs concerning the management of dental caries, used a slightly different carious lesion scale and used different questions (7, 8). As most GDPs in Upper Egypt do not make and use bitewing radiographs for caries lesion detection, the present questionnaire was,

based on the panels' comments, adopted for the Egyptian situation. The findings of the present study are in agreement with these European studies, which also found a wide disparity in diagnosis and in clinical decision-making. Remarkable aspects, however, were the participants' indications for restorative treatment of deep enamel lesions, as well as their indications for a dental crown as a method to manage severe dentine caries lesions. The approach chosen differs from modern, minimal invasive oral health care approaches (9, 20).

About one third of treatments provided by GDPs in their private clinics constituted restorations. Temporary restorations were almost one third of the total restorations made, and because of the high workload can be considered as an intermediate treatment. In government dental clinics temporary fillings were rarely provided and when they were, it was mainly because of the unavailability of other restorative materials and/or equipment.

Introduction of the Minimal Intervention Dentistry approach (20), of new dental restorative materials, in addition to the new dental education programme (2, 12, 21), may slowly improve the present oral health situation in Upper Egypt. The ART approach can partly improve the poor levels of preventive and restorative care (22).

## **Conclusions**

This study has shown that most GDPs in Upper Egypt have an operative-minded treatment philosophy and spend little time on preventive measures. The main treatment provided is removal of teeth. In cases where a plastic restoration is made, amalgam is first choice restoration material.

## **Competing interests**

All authors declare that they have no competing interests.

## **Authors' contributions**

AF, WvdS, JM, NC and JF participated in the design of the study. JM performed the statistical analysis. AF, WvdS, and JF carried out the study. AF, WvdS, JM, NC and JF contributed to writing the manuscript. All authors read and approved the final version.

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## **Chapter 3**

### **Acceptance and Discomfort from Atraumatic Restorative Treatment In Secondary School Students in Egypt**

This chapter is based on:

Farag A, Frencken JE. Acceptance and Discomfort from Atraumatic Restorative Treatment in Secondary School Students in Egypt. Med Princ Pract 2009; 18: 26-30

## **Abstract**

### ***Objectives:***

To assess the level of acceptance and discomfort experienced by secondary school students when undergoing an atraumatic restorative treatment (ART) restoration.

### ***Subjects and Methods:***

Ninety (90) secondary school students, aged 14 and 15 years, were included in the study. The ART restorations were prepared in 45 cavities and restored using an encapsulated high-viscosity glass-ionomer. The depth of the cavities was judged from radiographs and clinically; into outer, middle and inner 1/3 of dentine. Using a graded periodontal probe, cavity size was measured, into approximately half the width of the mesio-distal and bucco-lingual/palatinal distance of the occlusal surface. The students were asked about level of sensation experienced during cavity preparation immediately after completion of restoration. Chi square test was used to test the effect of cavity depth and size on sensitivity from the teeth.

### ***Results:***

Of the 90 students, 6 (6.6%) and 26 (29.2%) experienced pain and discomfort, respectively during cavity preparation, more often in large than in small cavities ( $p=0.003$ ) and in cavities extending into the inner 1/3 than in the middle and outer 1/3 of dentine ( $p<0.0001$ ). Only one student reported post-operative sensitivity.

### ***Conclusions:***

The ART approach to treat dental cavities was well accepted by this group of secondary school students. Only a few reported pain during cavity instrumentation, and this was more prevalent in large cavities and in cavities with the floor close to the pulp.

## Introduction

Although no epidemiological studies of dental caries have been carried out recently in Egypt, annual reports suggest that the prevalence and severity of dental caries amongst the younger population is high (1). Because oral health services are predominantly provided in urban areas, the rural populations face a shortage of basic services, including caries prevention and restoration of cavitated teeth. Dentists prefer to work in urban environments and those employed in rural areas often find that maintenance of the basic equipment required to perform traditional restorative care is lacking. This in turn reduces the possibility of providing restorative care in rural areas. Therefore, a different approach needs to be adopted if rural communities are not to be permanently excluded from the type of care available to urban communities.

Health authorities have, therefore, shown interest in an investigation of the appropriateness and acceptance of atraumatic restorative treatment (ART) in Egypt. No electricity or plumbed water supply is needed when ART is applied, as only hand instruments are used to remove carious tissues and apply adhesive dental materials to fill cleaned cavities and adjacent pits and fissures (2).

Although ART has been studied in a number of countries in different continents and has yielded qualitatively good results (3-6), the quality of ART restorations over time under the high cariogenic challenge found in Egyptian child populations has been questioned by a number of dentists in Egypt. Their worries, in particular, concerned the inability to remove infected dentine completely when using ART, and this was thought to predispose to development of secondary caries. This concern within the country's profession needed to be addressed, as these perceptions could inhibit introduction of the ART approach on a wider scale. Potential barriers to introducing new techniques in (oral) healthcare need to be addressed early if the introduction is to have a chance of success (7).

One of the advantages of ART, compared to the traditional restorative approach using rotary instrumentation, is the significantly lower level of dental anxiety reported in both children (8-9) and adults (10). However, the level of sensitivity experienced during cavity preparation using ART, by size and depth of the cavity, has not been reported. This article reports on the level of acceptance and discomfort experienced by secondary school students when undergoing an ART restoration.

## **Subjects and Methods**

### ***Sampling Procedure***

The ethical committee, comprising representatives of Minia University, Minia Local Government, Ministry of Education, Government Health Insurance and students' parents from Minia City in North Egypt, approved the study. All Form I students from 4 local government- allocated secondary schools constituted the study population. Students were examined clinically for dental caries status by the first author (AF), using the criteria developed by WHO (11). The first set of inclusion criteria comprised the presence of cavitated dentine lesions with openings wide enough for the smallest excavator to enter but without (suspected) pulp involvement. Students having teeth with pulp involvement and those suffering from pain that could not be treated with ART (e.g. from periodontal problems) were referred to a dentist. The second set of inclusion criteria were informed consent, absence of medical complications, history of active bruxism or teeth clenching and xerostomia.

### ***Implementation***

The ART treatment was performed by the first author (AF) in the well-equipped clinic of the Dental School of Minia University, from November 2001 to March 2002. The operator did not have any prior experience in placing ART restorations and had acquired its principles and directions from reading the literature. In order to simulate a field setting, only the dental chair, spittoon and operating light were used. No chair-side assistant was available. A junior staff member assisted in the administration of

the study. Before the treatment started, all students were individually instructed by the junior staff member about how best to clean their teeth.

### ***Treatment Procedure***

Isolation was achieved using cotton wool rolls; and cotton wool pellets were used to wet and dry the cavities. The ART approach consisted of removing plaque from the tooth surface with a probe and cotton wool pellets, and then opening the cavity with dental hatchets, removing soft carious tooth tissues with small and large excavators and filling the cavity and the adjacent pits and fissures with an encapsulated glass-ionomer (Fuji IX<sup>®</sup> GP Fast; GC, Japan). The capsules were mixed for 10 s. at 4000 rpm. in an amalgamator (Silamat; Vivadent, Liechtenstein) and placed in the capsule applicator (Capsule applicator II; GC, Japan).

Conditioning of the cavity and adjacent pits and fissures (Cavity conditioner; GC, Japan) preceded the placement of the glass-ionomer for half of the restorations. In the other half, cavities were first disinfected for 1 min. with a 2% chlorhexidine solution (Consepsis; Ultradent, USA) before being conditioned. The filled cavity and adjacent pits and fissures were kept under pressure of a gloved finger, rubbed with a thin coat of petroleum jelly for 30 sec. and coated with resin varnish (Fuji varnish; GC, Japan). Excess material was removed after bite check with articulating paper, using a sharp carver instrument (Ash, England).

The final restoration was coated with a layer of resin varnish (Fuji varnish; GC, Japan). Multiple-surface cavities were filled after placement of a metal matrix band and holder (Tofflemire retainer; USA) and wedges. Local anaesthesia was administered only once: to a student who insisted on being anaesthetised before the treatment started.

## ***Evaluation***

Immediately after the treatment session was completed, the operator questioned students as to whether or not they had experienced sensitivity (discomfort or pain) during cavity manipulation. They were also asked whether they had accepted the received treatment now and if they would choose it in the future. The size of cavity opening after completion of cavity cleaning was measured with a graded periodontal probe and rated as being smaller or larger than half the width of the surface in both mesial-distal and buccal-lingual/palatinal directions. After completion of the restoration, a bitewing radiograph was taken. One film was developed immediately and the other was stored in a refrigerator. The radiographs were used to assess depth of cavity in the outer 1/3, middle 1/3 or inner 1/3 of the dentine.

The operator also judged the depth of the cavity in the deepest part using a graded periodontal probe. As each grade is 1 mm and as the distance from the dento-enamel junction to the pulp chamber at the occlusal surface is on average 3 mm, outer, middle and inner 1/3 of the dentine could be measured by placing the periodontal against the cavity wall. As radiographic images are two-dimensional and, therefore, do not always project the actual depth clearly, particularly in small deep extensions, the final score for cavity depth was a combination of the radiographic image and the clinical assessment.

## ***Statistical Analysis***

The data were entered into an Excel (Microsoft, USA) data sheet and analysed by a statistician of the University of Cairo, using SAS software (SAS Institute, Cary, NC, USA). The Chi square test was used to compare proportions. Statistical significance was set at  $p < 0.05$ .

## Results

### *Disposition of Subjects*

A total of 90 students; 57 males and 33 females aged 14 and 15-years, met the inclusion criteria. The distribution of ART restorations by type of jaw, tooth type and type of cavity is presented in Table 3.1.

**Table 3.1:**

The percent distribution of ART restorations by type of jaw, tooth type and type and size of cavity: n = number of restorations.

	ART restoration		n (%)	
Type of jaw	Maxilla		22	(24.4)
	Mandible		68	(75.6)
Type of tooth	Premolar		6	(6.6)
	Molar		84	(93.4)
Type and size of cavity	Class I	small	39	(43.3)
	Class I	large	31	(34.5)
	Class II	small	8	(8.9)
	Class II	large	10	(11.1)
	Class IV	small	2	(2.2)

### *Acceptability of the ART Restorations*

The percent distribution of level of acceptance according to gender is presented in Table 3.2. All the students found the ART restorative treatment that they had received acceptable and all expressed their desire to be treated with ART again, if necessary, in the future.

**Table 3.2:**

The percent distribution of students according to level of acceptance, by gender: n = number of restorations.

Level of acceptability	Male		Female		Total	
	n	%	n	%	n	%
Accepted	51	(56.7)	25	(27.8)	76	84.4)
Accepted very much	6	(6.6)	8	(8.9)	14	15.6)
Total	57	(63.3)	33	(36.7)	90	(100)

### ***Sensitivity Experienced with ART***

Painful sensations during cavity preparation using ART were experienced by 4 (4.5%) males and 2 (2.2%) females, whilst 12 (13.5%) males and 14 (15.7%) females experienced some discomfort. The percent distribution of level of sensitivity experienced during ART cavity preparation, by type and size of cavity, is shown in Table 3.3. Within each group, pain and discomfort were experienced more often in large, than in small cavities ( $p=0.003$ ). The percent distribution of level of sensitivity experienced during ART cavity preparation is presented in Table 3.4 according to depth of cavity. Within each sub group, pain and discomfort were experienced more often in cavities that extended into the inner 1/3 of the dentine than in the middle and outer 1/3s of dentine ( $p<0.0001$ ).

Only one student reported post-operative sensitivity, which had disappeared by the 3-month evaluation period.

**Table 3.3:**

The percent distribution according to level of sensitivity experienced during ART cavity preparation by type and size of cavity: n = number of restorations.

Sensitivity	Class I	Class I	Class II	Class II	Class IV	Total
	small	large	small	large	small	
	n (%)	n (%)	n (%)	n (%)	n (%)	
No pain	30 (33.3)	15 (16.7)	6 (6.1)	4 (4.4)	2 (2.2)	57 (63.3)
Discomfort	8 (8.9)	11 (12.2)	2 (2.2)	5 (5.5)	0 (0)	26 (28.9)
Pain	1 (1.1)	5 (5.6)	0 (0)	0 (0)	0 (0)	6 (6.7)
No report	0 (0)	0 (0)	0 (0)	1 (1.1)	0 (0)	1 (1.1)
Total	39 (43.2)	31 (34.4)	8 (8.9)	10 (11.1)	2 (2.3)	90 (100)

**Table 3.4:**

The percent distribution of level of sensitivity experienced during ART cavity preparation, by depth of cavity: n = number of restorations.

Sensitivity	Outer 1/3	Middle 1/3	Inner 1/3	Total
	dentine	dentine	dentine	
	n (%)	n (%)	n (%)	
No pain	21 (23.3)	23 (25.6)	13 (14.4)	57 (63.3)
Discomfort	2 (2.2)	7 (7.8)	17 (18.9)	26 (28.9)
Pain	0 (0)	1 (1.1)	5 (5.6)	6 (6.7)
No report	0 (0)	0 (0)	1 (1.1)	1 (1.1)
Total	23 (25.6)	31 (34.4)	36 (40.0)	90 (100)

## Discussion

Previous studies have shown the ART approach using hand instruments to be less painful than the traditional approach using rotary instruments (8-10, 12) when managing dental cavities. Therefore, using a control group to study the level of sensitivity during ART cavity instrumentation, by size and depth, was considered unnecessary. Instead, a straightforward cross-sectional investigation was done to provide the required additional information about the applicability and level of sensitivity and acceptance of ART in an adolescent population in Egypt.

The level of pain reported by these students was low (6.6%) and appears to be lower than the level of pain (19.3%) reported by age mates from Pakistan (8). This finding was obtained despite the fact that the operator in the present study had had no prior experience in using ART when the study commenced. However, reporting ART after the treatment has been completed is a subjective form of assessment, which is culturally determined. It is known that children from different cultures have different strategies for coping with distress (13). Nevertheless, in line with other studies, the present one showed that the use of ART caused low levels of pain and discomfort in adolescents. A spin-off from the use of ART was that there was no need to resort to administration of local anaesthesia. This result is similar to that reported by Van Bochoven *et al.*, (14) who demonstrated that young children with a mean age of 7 years preferred ART, using hand instruments without local anaesthesia as the treatment for dental cavities, to the traditional approach using local anaesthesia and to ART and local anaesthesia. These findings indicate that children prefer hand instruments to rotary instruments and that ART without anaesthesia is preferred to ART with local anaesthesia. It is generally accepted that children do not like to be injected with local anaesthetics and have their teeth drilled (15). These two procedures are what many children mainly dislike about the traditional restorative methods of treating dental cavities.

Observations that larger-sized cavities and cavities with the floor close to the pulp cause significantly more pain and discomfort than smaller cavities and those with a base higher up in the dentine are not unusual.

All students treated accepted the ART approach when receiving a restoration for the first time. This, and the finding that only one student reported post-operative sensitivity, is in agreement with results reported on ART in similarly aged children by many researchers from different countries (16-21). The degree of acceptance of treatment and the level of sensitivity of restorative care observed in these students indicates that the dental profession in Egypt would have sufficient reason to embrace the ART approach and further its investigation. In doing this they would follow dental professionals in many countries, including those in the USA (22), UK (23) and the Netherlands (24).

## **Conclusion**

The ART approach to treating dental cavities was well received by this group of secondary school students. Only a few reported pain during cavity instrumentation, which was more prevalent in large cavities and in cavities extending close to the pulp.

## **Acknowledgement**

The first author is very grateful to Dr. Fayez Mohammed Hassan, Dr. Elham Moustafa Fawzy and Dr. Mushira Dahaba for the assistance she received during the implementation of the study.

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## **Chapter 4**

### **5-Year survival of ART restorations with and without cavity disinfection**

This chapter is based on:

Farag A , van der Sanden WJ, Abdelwahab H, Mulder J, Frencken J. 5-Year survival of ART restorations with and without cavity disinfection. J Dent. 2009; 37: 468-74.

## SUMMARY

### **Objectives:**

The null-hypothesis tested was that there is no difference between the survival of ART restorations with, and without, cavity disinfection among adolescents after 5 years.

### **Methods:**

Eligible students were allocated to one of the treatment groups. One operator placed a total of 90 restorations, 45 each per treatment group, in ninety 14 -15 year olds. Restorations were evaluated on replica models at baseline and after one and 5 years, by 2 calibrated and independent evaluators using the ART criteria. The independent variables were: gender, mean DMFT score at baseline, cavity size (small/large), cavity type (single- / multiple surfaces) and disinfected cavity (yes/no). Statistical analyses were done using the Kaplan-Meier method and log-rank test.

### **Results:**

The cumulative survival percentage and standard error for the 61 ART restorations with and without disinfection at evaluation year 5 were 85% (SE = 6.1%) and 80% (SE = 7.1%), respectively: not significantly different ( $p = 0.37$ ) from each other. The cumulative survival percentage and standard error for all ART restorations was 97% (SE = 2.0%) at evaluation year 1 and 82% (SE = 4.7%) at year 5, and it was 85% (SE = 5.4%) for single- and 77% (SE = 9%) for multiple-surface ART restorations at year 5. The cumulative survival percentage of all ART restorations at evaluation year 5 was statistically significant higher for boys than for girls ( $p = 0.03$ ).

### **Conclusions:**

Disinfecting a cavity cleaned according to ART with a 2% chlorhexidine solution is unnecessary. It is useful to introduce the ART approach systematically into the healthcare system in Egypt.

## Introduction

The prevalence and severity of dental caries amongst the younger population in Egypt is high (1). In one study the mean DMFT score among 7-15-year olds was 4.45. (2). In line with the distribution of the components of the DMFT index in most middle-income countries (3), the D-component is by far the highest (79%) (2). Poor oral hygiene, lack of preventive care, financial barriers to providing and receiving care, lack and mal-distribution of oral healthcare personnel and dental equipment, and fear regarding traditional restorative care are considered reasons for this high caries situation.

The Atraumatic Restorative Treatment (ART) approach has been developed initially to provide preventive and restorative care in countries that have a rudimentary oral health care system (4). Meanwhile, it has been demonstrated that the ART approach was more cost-effective than the traditional approach using amalgam (5). Furthermore, a meta-analysis reported high survival rates of single-surface ART restorations in primary and permanent posterior teeth. Unfortunately, there were insufficient data available for estimating the survival percentage of ART restorations in multiple-surface cavities in permanent teeth (6).

On the basis of results achieved in other Middle-Eastern countries (7-9), introduction of the ART approach into the Egyptian oral health care system was proposed. But as no study on ART had been carried out in Egypt, a decision to test the approach among adolescents was made. Moreover, an ART study was needed, as many dentists in many countries, including Egypt, have difficulty in accepting the modern concept of minimal intervention dentistry that allows affected dentine to remain behind in the process of cavity cleaning (10).

As chlorhexidine containing disinfectants have been shown to inactivate Streptococci species (11,12), it was thought that application of chlorhexidine solution in the cleaned cavity prior to restoring it would further reduce the bacterial load under ART

restorations using glass-ionomer cement. This step might also contribute to increasing the acceptance of the ART approach among dentists in Egypt.

The null-hypothesis tested was that there is no difference in the survival of ART restorations with, and without, cavity disinfection, among adolescents after 5 years.

## **Materials and Methods**

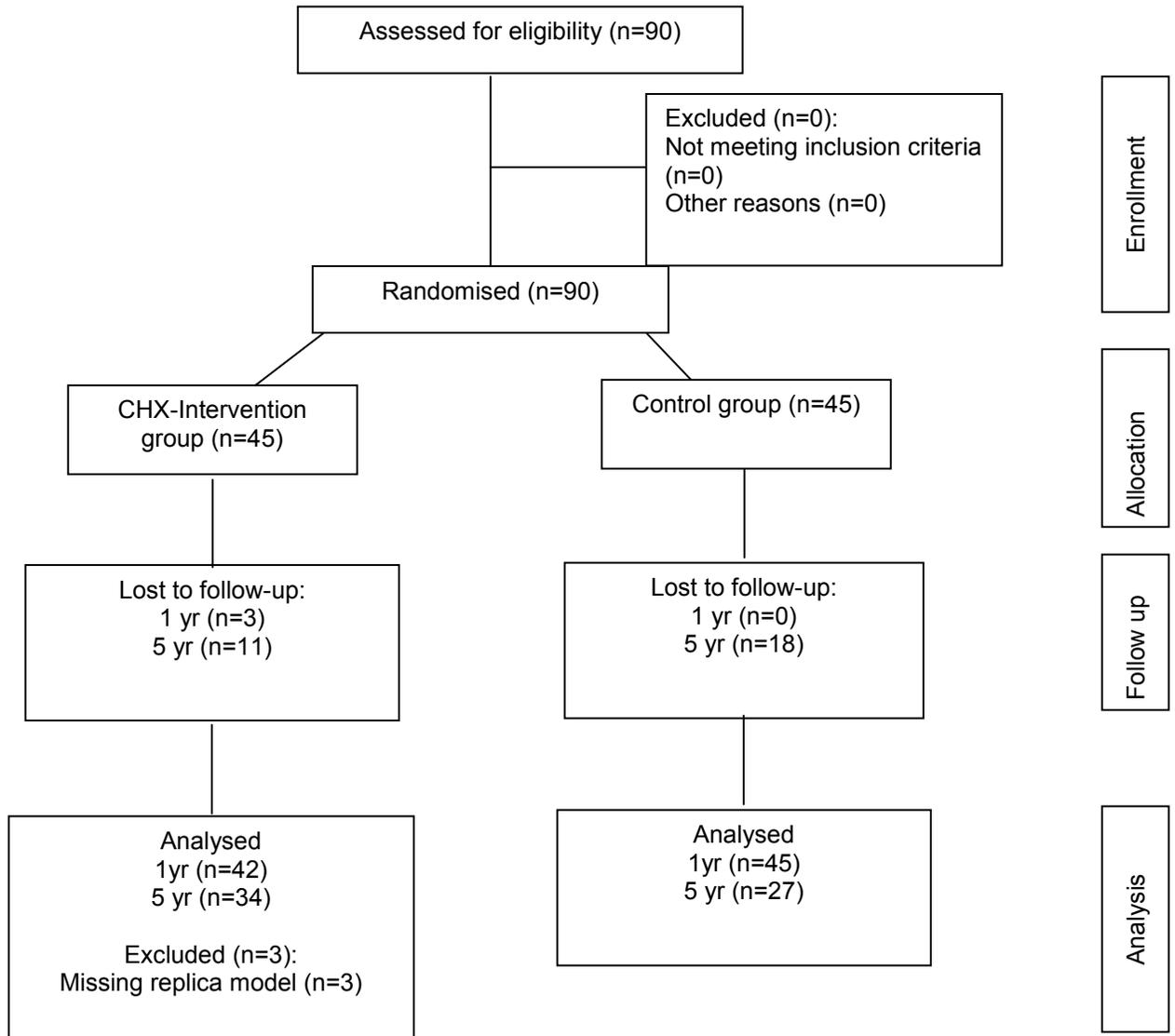
### ***Sampling Procedure***

The ethics committee, comprising representatives of Minia University, Minia Local Government, Ministry of Education, Government Health Insurance and students' parents from Minia City in Egypt, approved the study. The study population comprised all students from 4 local government-allocated secondary schools in Minia City. These schools were selected because local government had given permission to transport students in small groups to the Dental School for treatment, as the proximity of the schools to the Dental School allowed safe transportation under supervision.

Students were examined clinically for dental caries status at the school compound by the first author (AF), using the criteria developed by WHO (13). The first set of inclusion criteria comprised the presence of cavitated dentine lesions with openings wide enough for the smallest excavator to enter but without (suspected) pulp involvement. Non-eligible students, having teeth with pulp involvement, and those suffering from pain that could not be treated with ART were referred to a dentist.

The second set of inclusion criteria were: informed consent, absence of medical complications, and no history of active bruxism, teeth clenching, or xerostomia. Eligible students were quasi-randomly allocated to one of the treatment groups by the first author. The first student on the treatment list was allocated to Group A, the 2<sup>nd</sup> to Group B and the 3<sup>rd</sup> to Group A again. Composition of the treatment list followed the sequence of the clinical examination. Figure 4.1 shows a flowchart of the number of participants at each stage of the study, according to the Consort Statement.

**Figure 4.1:** Consort diagram showing all stages of the study (CHX = Chlorhexidine).



## Implementation

ART treatment was performed by the first author (AF) in the well-equipped clinic of the Dental School of Minia University, from November 2001 to March 2002. The

operator did not have any prior experience in placing ART restorations and had acquired its principles and directions from literature. In order to simulate a field setting, only the dental chair, spittoon and operating light were used. No chair-side assistant was available. A junior staff member assisted in the administration of the study. Before the treatment started, all students were individually instructed by the junior staff member about how best to clean their teeth. The junior staff member provided all other care required.

### ***Treatment Procedure***

Isolation was achieved, using cotton wool rolls, and cotton wool pellets were used to wet and dry the cavities. The ART approach involved opening the cavity with dental hatchets, removing soft carious tooth tissues with small and large excavators and filling the cavity and the adjacent pits and fissures with an encapsulated glass ionomer, Fuji IX GP Fast (GC, Tokyo, Japan). The capsules were mixed for 10s at 4,000 rpm/min in a Silamat amalgamator, (Vivadent, Schaan, Liechtenstein) and placed in a capsule applicator (GC, Tokyo, Japan). Conditioning of the cavity and adjacent pits and fissures, using Cavity Conditioner (GC, Tokyo, Japan), preceded the placement of glass ionomer. However, half of the cavities were first disinfected for 1 min with a 2% chlorhexidine solution, Consepsis (Ultradent, USA), before being conditioned with Cavity Conditioner.

The filled cavity and adjacent pits and fissures were kept under pressure of a gloved finger, rubbed with a thin coat of petroleum jelly for 30s and coated with Fuji resin varnish (GC, Tokyo, Japan). Excess material was removed after checking the occlusion with articulating paper, using a sharp carver instrument (Ash/Dentsply, Weybridge, England). The final restoration was coated with a layer of Fuji varnish (GC, Tokyo, Japan). Multiple-surface cavities were filled after placement of a metal matrix band and holder, Tofflemire retainer (Produits dentaires, Vevey, Switzerland) and proximal wedges.

Immediately after the treatment session was completed, the operator questioned students as to whether they had experienced sensitivity (discomfort or pain) during cavity manipulation.

The sensitivity also was assessed at one-year follow-up, by asking the participants whether they had experienced discomfort or pain after ART restoration. The results of this investigation have been reported elsewhere. (14).

### ***Evaluation***

The restorations were evaluated at baseline, after 1 and 5 years. Photographs were taken immediately after the restoration was completed, subsequently after one year, using a normal camera with a macro lens (Zenit12 KMZ, Moscow, Russia) and after 5 years, using a digital intraoral camera (Sopro 575, Acteon Group, France). Impressions were taken from all restored teeth at all 3 years of evaluation, using a polyvinyl silicone, addition - *type silicone elastomere impression* material, Affinis™ putty & light body (Coltène/Whaledent, Altstätten, Switzerland) in sectional impression trays, according to the manufacturer's instructions. Impressions were cast in high strength, low-expansion dental stone, Type IV, Glastone (Dentsply, York, USA) capable of reproducing fine details up to 50µm (15).

The size of cavity opening after completion of cavity cleaning was measured with a graded periodontal probe and rated as being smaller or larger than half the width of the surface in both mesial-distal and buccal-lingual/palatal directions.

The restorations were evaluated on replica models in accordance with the ART criteria (Table 4.1). The 0.5 mm ball-ended CPITN C-94 probe (Ash/Dentsply, Weybridge, UK) was used for measuring deficiencies at the restoration margin. Restorations with score 0 and 1 were considered successful, while scores 2–7 and 'C' were considered failures. A carious dentine lesion was diagnosed 'present' if the CPITN probe could penetrate the carious lesion.

If doubt existed, photographs were used to assist judgement. Two experienced and calibrated evaluators, one from the Netherlands and one from Egypt, carried out the assessments. The evaluators were involved in neither the planning of the study nor its execution. Differences between evaluators were discussed until consensus was reached.

**Table 4.1:**  
Evaluation criteria used to assess ART restorations

Code	Criteria
0	Present, satisfactory
1	Present, slight deficiency at cavity margin of less than 0.5mm*
2	Present, deficiency at cavity margin of 0.5mm or more*
3	Present, fracture in restoration
4	Present, fracture in tooth
5	Present, overextension of approximal margin of 0.5 mm or more*
6	Not present, most or all of restoration missing
7	Not present, other restorative treatment performed
8	Not present, tooth is not present
9	Unable to diagnose
C	Dentine carious lesion present

\* As assessed using the 0.5mm ball-end of a metal CPI probe; score 0 and 1 = survived

### ***Statistical analysis***

Data were analysed, using SAS version 9.1. The independent variables were gender, mean DMFT score at baseline, cavity size (small/large), cavity type (single - / multiple-surface) and disinfected cavity (yes/no). The dependent variable was restoration survival. The Kaplan-Meier method was used in estimating the survival

percentages. The t-test was used to check for a DMFT effect and the chi-square test, for gender, cavity size and cavity type effect on the test-experimental groups at baseline. The log-rank test was applied to test the null-hypothesis and for testing the effect of the independent variables on the restoration survival percentages.

## Results

The evaluators differed in 51/242 of the judgements (21%) over the 3 times of evaluation before reaching consensus. The differences predominantly concerned scores 0 and 1. In only 5 judgements (3 cases) did the difference have an effect on the survival results: 4 times the consensus score resulted in 'failure of the restoration' and once, in 'success'.

A total of 90 ART restorations were placed in 90 students, 57 males and 33 females, mean age of 14.6 years. There were 60 class I, and 30 class II cavities restored in molar (93%) and premolar (7%) teeth. Maxillary teeth were restored in 22/90 and mandibular teeth in 68/90 of the subjects. The mean DMFT score was 6.7 and the standard deviation was 2.3.

The restorations evaluated at 1 and 5 years by gender, cavity type, cavity size and treatment procedure are presented in Table 4.2. Three restorations were excluded from analysis as no replica models at evaluation year 1 were available. A total of 12 restorations failed; 3 at evaluation year 1 and 9 at evaluation year 5.

No statistically significant differences were observed between the two treatment groups with respect to the independent variables at baseline ( $p = 0.17$ ). The cumulative survival percentage and standard error for ART restorations with, and without, disinfection at evaluation year 5 were 85% (SE = 6.1%) and 80% (SE = 7.1%), respectively. The differences in cumulative survival percentages between the restorations in the two treatment groups over the 5-year evaluation period were not statistically significant ( $p = 0.37$ ). The cumulative survival percentage and standard error for all ART restorations was 97% (SE = 2.0%) at evaluation year 1 and 82% (SE = 4.7%) at evaluation year 5.

There was a gender effect ( $p = 0.03$ ) but no cavity type ( $p = 0.53$ ), cavity size ( $p = 0.89$ ) and DMFT effect ( $p = 0.19$ ) were observed for the cumulative survival percentages of all ART restorations over evaluation years 1 and 5.

**Table 4.2:** Cumulative survival (%) and Standard Error (SE) of ART restorations after 1 and 5 years by gender, tooth type, restoration size and procedure.

Survival	1 year		5 years		
Restoration	N	Survival $\pm$ SE (%)	N	Survival $\pm$ SE (%)	
<b>Overall</b>	87	97 $\pm$ 2.0	61	82 $\pm$ 4.7	
<b>Gender</b>					
Boys	55	98 $\pm$ 1.8	44	89 $\pm$ 4.6	$p=0.03$
Girls	32	94 $\pm$ 4.3	17	66 $\pm$ 10.8	
<b>Cavity type</b>					
Single-surface (CI 1)	57	96 $\pm$ 2.4	41	85 $\pm$ 5.4	$p=0.53$
Multiple-surfaces (CI 2)	30	97 $\pm$ 3.3	20	77 $\pm$ 9.0	
<b>Restoration size</b>					
Small	48	98 $\pm$ 2.0	31	82 $\pm$ 6.7	$p=0.89$
Large	39	95 $\pm$ 3.5	30	82 $\pm$ 6.6	
<b>Procedure</b>					
CHX	42	100 $\pm$ 0.0	34	85 $\pm$ 6.1	$p=0.37$
No-CHX	45	93 $\pm$ 3.7	27	80 $\pm$ 7.1	

N = Number of restorations placed;

CHX = Chlorhexidine; CI 1 = Black class 1 restoration; CI 2 = Black class 2 restoration. P value per category

## Discussion

The method used in evaluating the ART restorations in the present study has rarely been applied before (16). As the assessment of the quality of restorations is usually carried out clinically, allowing only a certain amount of time for assessing the state of the restoration with no opportunity given for reassessment if needed, the present evaluation was done on replica models of all restorations over the 3 years of evaluation. This procedure provides sufficient time for assessment, as well as allowing the possibility for discussion of the ratings of all clinical cases. It enhances the quality of restoration assessment and consequently, the reliability of its outcomes. Therefore, the findings of the present study reflect, in close approximation, the true state of the restorations over time.

It is suggested that producing replica models should become the standard procedure for assessing the quality of restorations and sealants, particularly when the study involves a manageably low number of restorations or sealants. Therefore, a reliability test using kappa statistics was not used. Such a test would be needed only for evaluation of large numbers of restorations or sealants.

All possible efforts were exercised to trace participating students over the evaluation period. This resulted in a high follow-up percentage at evaluation year 1, when students were still at school, but at a lower percentage at evaluation year 5 when participants had to be visited at their home and place of work.

The null-hypothesis was accepted. After one and 5 years no difference was found in the survival of ART restorations with, and without, disinfection of the cavity before filling. This finding is in agreement with those for (non-) cavity disinfected ART restorations in primary posterior teeth after 2 years (17). The survival rate of cavity disinfected ART restorations after 1 and 5 years in the present study were slightly higher than those for non-cavity disinfected ART restorations. Whether this insignificant difference should be considered a trend is difficult to say using the

current study design. As no study on this topic was available at the time when the sample size for this comparison was obtained, it is realistic to look at methodological issues such as sampling size, in forthcoming studies on this topic. Such studies could include the effect of chlorhexidine disinfectant on the bonding of glass-ionomer cement to caries affected dentine (18) and on the inhibition of micro-organisms (19), and of matrix metalloproteinase's in cleaned cavities using the ART approach. However, the present study implies that it is not necessary to disinfect the cavity when a permanent tooth is being restored according to the ART approach.

The 5-year survival rate of single-surface ART restorations using encapsulated high-viscosity glass-ionomer cement, in the now 20-year-old adults, in the present study (85%) is somewhat higher than the weighted mean survival scores of comparable restorations using hand-mixed high-viscosity glass-ionomer cement after 5 years (79%) as reported in the meta-analysis for 12-year-old children (6). As the large majority of ART restoration survival studies have used hand-mixed glass-ionomers it is unrealistic to discuss the effect of the different modes of glass-ionomer application on the survival of ART restorations. Nevertheless, it has been suggested that encapsulated glass-ionomer cement might be a potential solution to the observed operator induced variability associated with hand-mixed glass-ionomer cements (20).

The 5-year survival rate of single-surface ART restorations in the present study is similar to that of single-surface amalgam restorations (89.5%) but somewhat lower than that of resin composite restorations (91%) after 5 years (21). Because most of the published ART studies have been carried out on young children (7 - 8 year-olds), the numbers of multiple surface ART restorations placed in those children were low (22) and others may, therefore, not have reported these findings in the literature.

One study reported the survival (92%) of multiple-surface ART restorations after 6 months for a low sample size amongst, on average, 12 year-olds (23). Therefore, despite the low number of multiple-surface ART restorations evaluated, the 5-year survival percentage observed in the present study should be considered a 'first marker'. Clearly, more studies assessing substantial numbers of multiple-surface ART

restorations in permanent teeth over a long time period are indicated. Such studies would perhaps also assist in explaining why, in the present study, boys had higher survival rates of ART restorations than girls.

Considering the absence of restorative care in many parts of Egypt, the high survival percentages obtained in the present study, the introduction of ART into the healthcare system should be seriously considered by those in authority.

## **Conclusion**

There is no need to disinfect a cavity cleaned according to the ART approach with a 2% chlorhexidine solution for one minute, before restoring it with a high-viscosity glass-ionomer cement. The 5-year survival percentages of ART restorations were high. The ART approach should be introduced and adopted in the healthcare system of Egypt. Production of replica models for assessing the state of restorations is recommended.

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## **Chapter 5**

### **Survival of ART restorations, assessed using the FDI and the ART restoration criteria**

This chapter is based on:

Farag A, van der Sanden WJ, Abdelwahab H, Frencken JE. Survival of ART restorations, assessed using the FDI and the ART restoration criteria. Clin Oral Invest 2011;15: 409-15.

## **Abstract**

A new set of criteria for assessing the quality of restorations using modern restorative materials, named FDI criteria, was recently introduced. This study tested the hypothesis that there is no difference in survival percentages of ART restorations assessed using FDI and ART criteria after one and five years. One operator placed a total of 60 class I and 30 Class II high-viscosity glass-ionomer ART restorations in ninety 14- to 15-year-olds. Two calibrated and independent evaluators using both criteria evaluated restorations on replica models at baseline and after one and 5 years. Statistical analyses were done using the Kaplan-Meier method and log-rank test. The survival results of ART restorations assessed using both sets of criteria after 1 and 5 years did not differ statistically significantly. The hypothesis was, therefore, accepted. Three ART restorations were assessed as failures according to the ART criteria, while assessment using the FDI criteria regarded them as having survived. The conclusion was that the ART criteria are more stringent than the FDI criteria and the ART criteria enable reliable assessment of ART restorations in permanent teeth, from models.

## Introduction

Criteria for assessing the clinical performance of restorations need to be reliable, pragmatic and easy to use. During the last three decades, most researchers have used the Ryge criteria for evaluating different restoration materials. However, researchers have over time adapted these criteria, in an effort to make them more discriminating in relation to modern restorative materials. Consequently the alterations resulted in the need for names identifying particular sets of criteria; such as the modified Ryge or modified United States Public Health Service (USPHS) criteria (1).

As part of the development of the ART approach, more than two decades ago restoration and sealant assessment criteria were created for use with ART (2). In that developmental stage, special attention was given to the expected weakness of the restorative material used then for ART (medium-viscosity glass-ionomer). Also regarded as extremely important was the need for reliable application of the criteria by researchers throughout the world, to facilitate reliable restoration survival comparison of this new caries management approach.

The original set of ART restoration criteria has, meanwhile, been modified, as the first survival studies did not reveal the anticipated substantial level of restoration surface wear (3, 12). Most studies investigating ART restoration survival have used the original and the modified ART restoration assessment criteria (13). A few studies have used both the USPHS and the ART criteria to assess restoration quality. One study found that both criteria were comparable (7), while Lo et al. (10) concluded that the ART criteria were more stringent than those of the USPHS. The suggestion by Lo et al (10) seems in conflict with the conclusion of investigators who claim that the Ryge / USPHS criteria have limited sensitivity for detecting the improved clinical performance of the restorative materials currently in use (6). In many cases the insensitivity of the Ryge criteria is misinterpreted as good clinical performance (6).

Therefore, in order to detect early deterioration and differences between restorations using modern restorative materials, a new discriminative set of criteria, named FDI criteria, was developed (6). It focuses on the clinical performance of the restorative materials, including their aesthetic, functional and biological properties, and would allow for a more detailed analysis of failures.

As the FDI evaluation criteria have recently been introduced, they need to be compared to other existing restorative assessment criteria. The current study tests the hypothesis that there is no difference in survival percentages of ART restorations when assessed using the FDI and the ART criteria after one and five years.

## **Materials and Methods**

The clinical study was carried out among 90 secondary students aged 14.5 years in Minia City, Egypt. The ethics committee, comprising representatives of Minia University, Minia Local Government, Ministry of Education, Government Health Insurance and students' parents from Minia City, approved the research.

### ***Implementation***

ART treatment was performed by the first author (AF) in the well-equipped clinic of the Dental School of Minia University, from November 2001 to March 2002. The operator did not have any prior experience in placing ART restorations and had acquired its principles and directions from reading the literature. In order to simulate a field setting, only the dental chair, spittoon and operating light were used. No chair side assistant was available. A junior staff member assisted in the administration of the study and, before the treatment started, individually instructed all students on how best to clean their teeth.

### ***Treatment Procedure***

The main study was intended to determine whether the use of chlorhexidine solution prior to restoration of the cleaned cavity would result in higher restoration survival

rates. Therefore, half of the cavities were first disinfected for 1 min with a 2% chlorhexidine solution, Consepsis (Ultradent, USA), before being conditioned with Cavity Conditioner. The treatment procedures are described in detail in a previous publication (1). The size of cavity opening after completion of cavity cleaning was measured with a graded periodontal probe and rated as being smaller or larger than half the width of the surface in both mesial-distal and buccal-lingual/palatal directions.

### ***Evaluation***

The restorations were evaluated at baseline, after 1 and 5 years. Photographs were taken immediately after the restoration was completed; subsequently after one year, using a normal camera with a macro lens (Zenit12 KMZ, Moscow, Russia) and after 5 years, using a digital intraoral camera (Sopro 575, Acteon Group, France). Impressions were taken from all restored teeth at all 3 years of evaluation, using a polyvinyl silicone, addition - type silicone elastomere impression material, Affinis™ putty & light body (Coltène/Whaledent, Altstätten, Switzerland) in sectional impression trays, according to the manufacturer's instructions. Impressions were cast in high-strength, low-expansion dental stone, Type IV, Glastone (Dentsply, York, USA), capable of reproducing fine details up to 50µm (5).

The restorations were evaluated on replica models according to the ART criteria (Table 5.1) and the newly developed FDI criteria (Table 5.2). If doubt arose, photographs were used to assist in making a judgment. In applying the ART criteria, deficiencies at the restoration margin were measured, using the 0.5 mm ball-ended CPI probe (CPITN-C-94, Ash/DENTSPLY, UK). A dentine carious lesion was scored 'present' if the CPI probe could penetrate the lesion. Restorations with scores 0 and 1 were considered as having survived, while scores 2–7 and 'C' were considered failures according to the ART criteria. As the assessment was performed extra-orally, not all features of the FDI criteria could be scored. Two specially designed probes with diameters of 150 µm and 250µm (DEPPELER, Rolle, Switzerland) were used to measure deficiencies at the restoration margin, using the FDI criteria. The ICDAS criteria were used in the restored teeth for diagnosing the presence of carious lesions

(8). A cavitated dentine carious lesion was scored if a CPI probe could enter the cavity. According to the FDI criteria, restorations with scores 1, 2 and 3 are considered as having survived, whereas scores 4 and 5 indicate a failure.

Two experienced and calibrated evaluators, one from the Netherlands and one from Egypt, conducted the evaluation. They were involved in neither the planning of the study nor its execution. The inter-evaluator consistency tests for assessing restoration survival and diagnosing dentine carious lesions, expressed as kappa coefficient and P-observed value, were carried out using all the replica models at evaluation year 1 and 5. The Landis and Koch criteria (9) were used to quantify the test outcomes. Differences between evaluators were discussed and consensus was reached on all initial differences.

**Table 5.1:** ART evaluation criteria used to assess ART restorations

Code	Criteria
10	Present, satisfactory
11	Present, slight deficiency at cavity margin of less than 0.5mm*
12	Present, deficiency at cavity margin of 0.5mm or more*
13	Present, fracture in restoration
14	Present, fracture in tooth
15	Present, overextension of approximal margin of 0.5 mm or more*
16	Not present, most or all of restoration missing
17	Not present, other restorative treatment performed
18	Not present, tooth is not present
19	Unable to diagnose
C	Dentine carious lesion present

\* As assessed using the 0.5mm ball-end of a metal CPI probe

### ***Statistical analysis***

Data were analysed, using SAS version 9.1. The independent variables were gender, mean DMFT score at baseline, cavity size (small/large), cavity type (single - / multiple-surface) and disinfected cavity (yes/no). The dependent variable was restoration survival. The Kaplan-Meier method was used in estimating the survival percentages. The t-test was used to check for a DMFT effect and the chi-square test, for gender, cavity size and cavity type effect on the test-experimental groups at baseline. The log-rank test was applied in testing the null-hypothesis and the effect of the independent variables on the restoration survival percentages.

## **Results**

### ***Quality of the data***

The results of the inter-examiner consistency tests using ART and FDI criteria are presented in Table 5.3. As no 2x2 contingency table could be constructed for the survival of ART restorations at evaluation year 1, restoration survival scores of evaluation years 1 and 5 were presented as combined. The reliability of assessing the FDI criteria properties fractures and retention, marginal adaptation and tooth integrity was found to be substantial. It was found fair for the property wear, while moderate for diagnosing dentine carious lesions. The percentage of observed agreement was very high for all the properties of both assessment criteria, ranging from 0.92 to 1.00.

Before reaching consensus the evaluators differed in 51/242 of the judgements (21%) using the ART criteria over the 3 times of evaluation. The differences predominantly concerned scores 0 and 1. In only 5 judgements (3 cases) did the difference have an effect on the survival outcome: 4 times the consensus score resulted in 'failure of the restoration' and once, in 'success'. Four of the 5 judgements concerned the diagnosis of dentine carious lesions which resulted in 3 failures.

Using the FDI criteria, the evaluators differed in 6/242 judgements for fractures and retention, in 27/242 judgements for marginal adaptation, in 13/242 judgements for wear and in 5/242 judgements for tooth integrity, before reaching consensus.

In 6 judgements (4 cases) the difference had an effect on the survival outcome; 4 times the consensus score resulted in success and twice, (2 cases) in failure of the restoration. These latter two cases, each for fractures / retention, and wear, had no failure scores for the other 3 restoration properties.

**Table 5.3:** Inter-evaluator consistency assessments using kappa coefficient, its Standard Error (SE) and percentage correct observed scores (Pobs) for assessing restoration failure (yes/no) and diagnosing dentine carious lesions by evaluation year using the FDI and ART criteria.

FDI criteria	Evaluation year											
	1				5				1 and 5 combined			
	N	Kappa	SE	P <sub>obs</sub>	N	Kappa	SE	Pobs	N	Kappa	SE	Pobs
Fracture	86	1.0	0.0	1.0	62	0.82	0.13	0.97	148	0.83	0.12	0.99
Marginal adaptation	86	1.0	0.0	1.0	62	0.73	0.18	0.97	148	0.74	0.17	0.99
Wear	86	1.0	0.0	1.0	62	0.38	0.28	0.95	148	0.39	0.28	0.98
Integrity	85	1.0	0.0	1.0	62	0.79	0.20	0.98	147	0.80	0.20	0.99
Restoration survival	85	1.0	0.0	0.0	62	0.84	0.11	0.98	147	0.85	0.10	0.99
ART criteria												
Restoration survival	87	N/A			62	0.80	0.11	0.95	149	0.68	0.12	0.96
ART / FDI												
Dentine carious lesion	85	1.0	0.0	1.0	61	0.50	0.19	0.92	146	0.53	0.18	0.97

### ***Disposition of restorations***

A total of 90 ART restorations were placed in 90 students: 57 males and 33 females, with a mean age of 14.6 years. There were 60 class I, and 30 class II cavities restored in molar (93%) and premolar (7%) teeth.

Maxillary teeth were restored in 22/90, and mandibular teeth in 68/90 of the subjects. The mean DMFT score was 6.7 and the standard deviation was 2.3.

### ***Restoration survival***

The restorations evaluated at 1 and 5 years by gender, cavity type, cavity size and treatment procedure, by the ART and FDI criteria, are presented in Table 5.4. Three restorations were excluded from analysis, as no replica models at evaluation year 1 were available.

A total of 12 restorations failed: 3 at evaluation year 1 and 9 at evaluation year 5, according to the ART criteria. According to the FDI criteria, 9 restorations failed: 1 at evaluation year 1 and 8 at evaluation year 5 (Table 5.5). All the 3 ART restorations that failed according to the ART, and those that survived according to the FDI, criteria had a score of 2 in relation to the ART criteria.

**Table 5.4:** Cumulative survival (%) and Standard Error (SE) of ART restorations assessed using the ART and FDI criteria after 1 and 5 years by gender, tooth type, restoration size and procedure.

Survival Restoration	1 year		5 years		
	N	Survival ± SE (%)	N	Survival ± SE (%)	
<b>Overall</b>					
ART	87	97 ± 2.0	61	82 ± 4.7	
FDI	87	99 ± 1.1	61	86 ± 4.4	
<b>Gender</b>					
Boys					
ART	55	98 ± 1.8	44	89 ± 4.6	p=0.03
FDI	55	98 ± 1.8	44	89 ± 4.6	p=0.28
Girls					
ART	32	94 ± 4.3	17	66 ± 10.8	
FDI	32	100 ± 0.0	17	76 ± 10.3	
<b>Cavity type</b>					
Single-surface (cl 1)					
ART	57	96 ± 2.4	41	85 ± 5.4	p=0.53
FDI	57	98 ± 1.7	41	89 ± 4.8	p=0.44
Multiple-surfaces (cl 2)					
ART	30	97 ± 3.3	20	77 ± 9.0	
FDI	30	100 ± 0.0	20	80 ± 8.9	
<b>Restoration size</b>					
Small					
ART	48	98 ± 2.0	31	82 ± 6.7	p=0.89
FDI	48	100 ± 0.0	31	87 ± 6.0	p=0.66
Large					
ART	39	95 ± 3.5	30	82 ± 6.6	
FDI	39	97 ± 2.5	30	84 ± 6.4	
<b>Procedure</b>					
Chlorhexidine					
ART	42	100 ± 0.0	34	85 ± 6.1	p=0.37
FDI	42	100 ± 0.0	34	85 ± 6.1	p=0.98
No-Chlorhexidine					
ART	45	93 ± 3.7	27	80 ± 7.1	
FDI	45	98 ± 2.2	27	87 ± 6.2	

N = Number of restorations placed;

cl 1 = Black class 1 restoration; cl 2 = Black class 2 restoration

P-value is per independent variable

The cumulative survival percentage and standard error for all ART restorations assessed using the ART criteria was 97% (SE = 2.0%) at evaluation year 1 and 82% (SE = 4.7%) at evaluation year 5. The corresponding figures for ART restorations assessed using the FDI criteria were 99% (SE = 1.1%) at evaluation year 1 and 86% (SE = 4.4%) at evaluation year 5. Only one significant effect was observed between the dependent and the independent variables in data assessed by ART and FDI criteria at 5 years. This concerned a gender effect ( $p = 0.03$ ) for ART restorations assessed according to the ART criteria (Table 5).

**Table 5.5:** Failed ART restorations according to the ART and FDI criteria at 1 and 5 years evaluation.

Tooth number	ART criteria	FDI Criteria				
		Fracture	Adaptation	Wear	Caries	Marginal integrity
1 year						
37	6	F	s	s	s	s
16	2	s	s	s	s	s
37	2	s	s	s	s	s
5 years						
36	4	F	F	F	F	F
36	3	s	s	F	s	s
36	C	s	s	s	F	s
26	2	F	s	s	s	s
47	C	s	s	s	F	s
36	2	s	s	s	s	s
16	3	F	F	s	F	s
37	C	s	s	s	F	s
16	3	F	F	s	F	s

s = successful; F = failure; C = dentine carious lesion

## Discussion

The percentage of correctly observed judgements (Pobs) was used to complement the reliability measurement coefficient Kappa. This was necessary as the kappa statistic is unreliable in low prevalence populations such as the present one. As all Pobs readings and most of the kappa coefficients were high, it was concluded that the quality of the data was high.

In the process of using the ART approach to restore an occlusal cavity, both the cavity and the pits and fissures are filled. An ART restoration is, therefore, a sealant restoration (2). This implies that restorative material, usually a high-viscosity glass-ionomer, is not placed only in the cavity but also, very frequently in occlusal surfaces, over its margin. In this aspect, ART restorations differ from resin composite or amalgam restorations, which aim to finish the restoration at the cavity margin, leaving pits and fissures unfilled.

It is known that glass-ionomer, like other directly placed restorative materials, deteriorates over time. Deterioration is particularly noticeable in glass-ionomer sealants (4). In a number of cases in the present study, the sealant part of the glass-ionomer ART restoration had clinically disappeared, leaving an inverse step visible towards the restoration part of the ART restoration. This condition, considered by the evaluators to be either a marginal gap (failure) or not (success), was the main reason influencing their disagreement about the survival outcome. However, the marginal gap can be mistaken as the inverse step instead of a real gap at the marginal, exposing enamel and or dentine. Such a difficulty in using the ART criteria had not been reported before, which is most probably due to the sufficient time available for assessing the ART restorations and discussing different outcomes amongst evaluators from models. In future glass-ionomer ART studies, evaluators should pay attention to the phenomenon of the inverted step when assessing ART restorations in occlusal surfaces. The presence of an inverse step is not considered a failure.

The survival results of ART restorations assessed in accordance with both assessment criteria after 1 and 5 years did not differ statistically significantly. The hypothesis was accepted. A difference was apparent in 3 ART restorations that were assessed as 'failure' according to the ART criteria and as 'sound' according to the FDI ones. All 3 ART restorations had a score of 2, which means that more than 0.5 mm of enamel was visible at any part of the cavity wall. The FDI criteria accept the total length of visible enamel as sound, only considering a marginal gap of >0.25mm or exposed dentine as a condition indicating failure of a restoration in the category 'marginal adaptation' (6). According to the Ryge criteria, only exposed dentine would be a reason for failing a restoration in the category 'marginal integrity' (11). The outcome of the present study shows that the ART criteria are more stringent than the FDI criteria in assessing ART restoration survival in permanent teeth. This finding is in line with the observation made by Lo et al (10), who found the ART criteria to be more stringent than the Ryge criteria (11).

Another difference between the 2 sets of criteria used in the present study is the absence of extracted restored and reresored teeth in the data base of the survival analyses using the FDI criteria. The same is also applicable when the ART criteria are compared to the Ryge criteria. As the survival of ART restorations in the present study was based on the restoration assessment outcomes from models only, the omission of re-restored teeth and of extracted restored teeth had no influence on the final outcome. However, inclusion or exclusion of extracted restored teeth and re-restored teeth does make a difference in survival percentages of restorations. It is, therefore, safe to say that if the ART restorations in the published literature had been assessed using the Ryge criteria, the reported survival of ART restorations would have been higher.

The present study has shown that the ART criteria provide a reliable measurement instrument for assessing ART restoration survival. They cover less detail than the FDI criteria but are easier and faster to use. It is therefore recommended that the ART criteria be used for restoration and tooth survival assessment in clinical health

services studies and that the FDI criteria be used for studying the quality of restorative materials only (6).

In conclusion: the ART criteria make reliable assessment of ART restorations in permanent teeth from models possible and they are more stringent than the FDI criteria.

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Table 5.2: The FDI evaluation criteria used to assess ART restorations

Functional (5-7) and biological properties (12,13)	5. Fractures and retention	6. Marginal adaptation	7. Wear	12. Recurrence of caries, erosion, abfraction	13. Tooth integrity (enamel cracks)
1. Clinically excellent / very good	5.1 Restoration retained, no fractures / cracks	6.1 Harmonious outline, no gaps, no discoloration.	7.1 Physiological wear equivalent to enamel (80-120% of corresponding enamel)	12.1 No secondary or primary caries	13.1 Complete integrity.
2. Clinically good (after polishing very good)	5.2 Small hairline crack.	6.2.1 Marginal gap (50 µm). 6.2.2 Small marginal fracture removable by polishing.	7.2 Normal wear with only slight difference to enamel (50-80% or 120-150% of corresponding enamel)	12.2 Very small and localized 1. Demineralization 2. Erosion or Abfraction. No operative treatment required	13.2.1 Small marginal enamel split (<150 µm). 13.2.2 Hairline crack in enamel (<150 µm not probable).
3. Clinically sufficient/satisfactory (minor shortcomings, no unacceptable effects but not adjustable w/o damage to the tooth).	5.3 Two or more or larger hairline cracks and/or chipping (not affecting the marginal integrity or proximal contact).	6.3.1 Gap < 150 µm not removable 6.3.2. Several small enamel or dentin fractures	7.3 Differing wear rate to enamel but within the biological variation (<50% or 150-300% of corresponding enamel)	12.3 Larger areas of 1. Demineralisation, 2. Erosion or 3. Abrasion /abfraction but only preventive measures necessary (dentine not exposed)	13.3.1 Enamel split < 250 µm 13.3.2 Crack <250 µm; no adverse effects.
4. Clinically unsatisfactory (but repairable)	5.4 Chipping fractures which damage marginal quality or proximal contacts; bulk fractures with or without partial loss (less than half of the restoration).	6.4.1 Gap > 250 µm or dentine/base exposed. 6.4.2. chip fracture damaging margins 6.4.3 Notable enamel or dentine wall fracture	7.4 Wear considerably exceeds normal enamel wear; or occlusal contact points are lost (restoration > 300% of enamel wear or antagonist >300%)	12. 4.1 Caries with cavitation 12.4.2 Erosion in dentine 12.4.3 Abrasion/abfraction in dentine. Localized and accessible and can be repaired	13.4.1 Major enamel split (gap > 250 µm or dentine or base exposed). 13.4.2 Crack >250 µm (probe penetrates).
5. Clinically poor (replacement necessary)	5.5 (Partial or complete) loss of restoration.	6.5 Filling is loose but in situ.	7.5 Wear is excessive (restoration or antagonist > 500% of corresponding enamel)	12.5 Deep secondary caries or exposed dentine that is not accessible for repair of restoration.	13.5. Cusp or tooth fracture



## **Chapter 6**

### **Introduction of the ART approach in Egypt: intentions, clinical effects and perceived barriers. A cohort study**

This chapter is based on:

Farag A, van der Sanden WJ, Mulder J, Creugers NH, Frencken JE. Introduction of the ART approach in Egypt: intentions, clinical effects and perceived barriers. A cohort study. Accepted, Acta Odontol Scand, 2012.

## Abstract

**Aim:** The aim of this cohort study was to evaluate the effect of the introduction of ART in Upper Egypt and assess the participating General Dental Practitioners' (GDPs) opinions, intentions, and expectations and perceptions regarding barriers related to using ART.

**Methods:** 35 GDPs were selected and trained on ART for 5 days. Knowledge assessments were done immediately before and after the training, using a questionnaire. Regular evaluation and assessment data were collected after 6 and 12 months, through questionnaires with closed and open-ended questions. Clinical data in government and private clinics were collected, using clinical record forms. GDPs' opinions, intentions, expectations and perceptions regarding barriers related to ART were assessed, through questionnaires, at start and after one year. The control group comprised 35 other GDPs.

**Results:** At start, the most GDPs intended to make ART restorations. After 1 year 65% and 97% actually made ART restorations in their government and private clinics, respectively. The barriers faced by the GDPs to making ART restorations in the government clinics were mainly unavailability of suitable restoration material and of hand instruments. After 1 year post training, ART restorations constituted 41% of the total plastic restorations made. Finally, the majority of GDPs believe that ART is suitable for use in their government and private practices.

**Conclusion:** All participating GDPs intended to introduce ART in their government and private clinics. They successfully introduced this technique in their private clinics but, owing to the unavailability of suitable instruments and restoration materials, failed to do so in the government clinics. They liked the simplicity of the technique.

## Introduction

Dental caries is the most widely spread oral disease in the world (1). Untreated dental caries is a global public health problem, especially in low- and middle-income countries like Egypt. It is the main reason for tooth loss (2-4). The population in rural and suburban areas of Egypt, in particular, is suffering from high caries prevalence with unmet needs (5). Information about the Egyptian oral health care system is presented in Box 6.1. All general dental practitioners (GDPs) have to work in a government dental clinic, and most of them also have their own private dental clinic(s).

In the late nineteen eighties, restorative care constituted less than 1%, while tooth extractions constituted 53%, of the total dental treatment provided in Egyptian government dental clinics in rural areas (6). That pattern of care appears not to have changed over the years, as extraction rather than restorative treatment of cavitated carious teeth is currently the common treatment provided by general dental practitioners (GDPs). Moreover, the dentist-population ratio in rural areas of Upper Egypt, where 60% of the Egyptian population lives, is low (7).

The Atraumatic Restorative Treatment (ART) approach was suggested as an alternative or complementary treatment model for improving the presently poor level of preventive and restorative care (7). Substantiating factors regarding the implementation of ART in Egypt were: the high survival rate of ART sealants and restorations (8, 9); the high survival rate of ART restorations after 5 years amongst secondary scholars in Egypt and the high level of acceptance of ART by these scholars (10, 11); the reasonably successful introduction of ART into the public health services of South Africa (12) and Tanzania (13). Furthermore, it was noted that the beneficial cost-effectiveness of the ART approach compared to the costs of conventional restorative care might make it suitable for applicability in Egypt (14, 15,).

Implementation of the ART approach in the oral health care services in conjunction with caries-preventive measures might lower the frequency of extractions and contribute to an increase in the number of restored teeth, slowly improving the oral

health status of the Egyptian population. Introduction of the ART approach and caries-preventive measures into the healthcare system in Egypt requires, firstly, a well-structured training course and secondly, a scheme for monitoring and evaluation of the clinical activities after completion of the training course. A better insight in GDPs' opinions and preferences on ART might be helpful during this process (12, 16-17).

The aims of this study were: 1) to assess GDPs' opinions regarding the introduction and use of the ART approach and caries-preventive measures; 2) to assess the expected and experienced barriers factors relevant to this introduction; 3) to evaluate GDPs' first clinical ART experiences.

## **Methods**

The study protocol was approved by Minya University, Faculty of Dentistry, Egypt (ERC/2010/12), and was registered in the Netherlands Trial Register (NTR2719). Willingness and permission to allow GDPs to participate in this study were granted by the health authorities of the Ministry of Health (MOH), Cairo, and the Egyptian Health Insurance Organization (HIO). Questionnaires and clinical recording forms were evaluated for appropriateness by a panel of three experienced GDPs, and modified according to their comments.

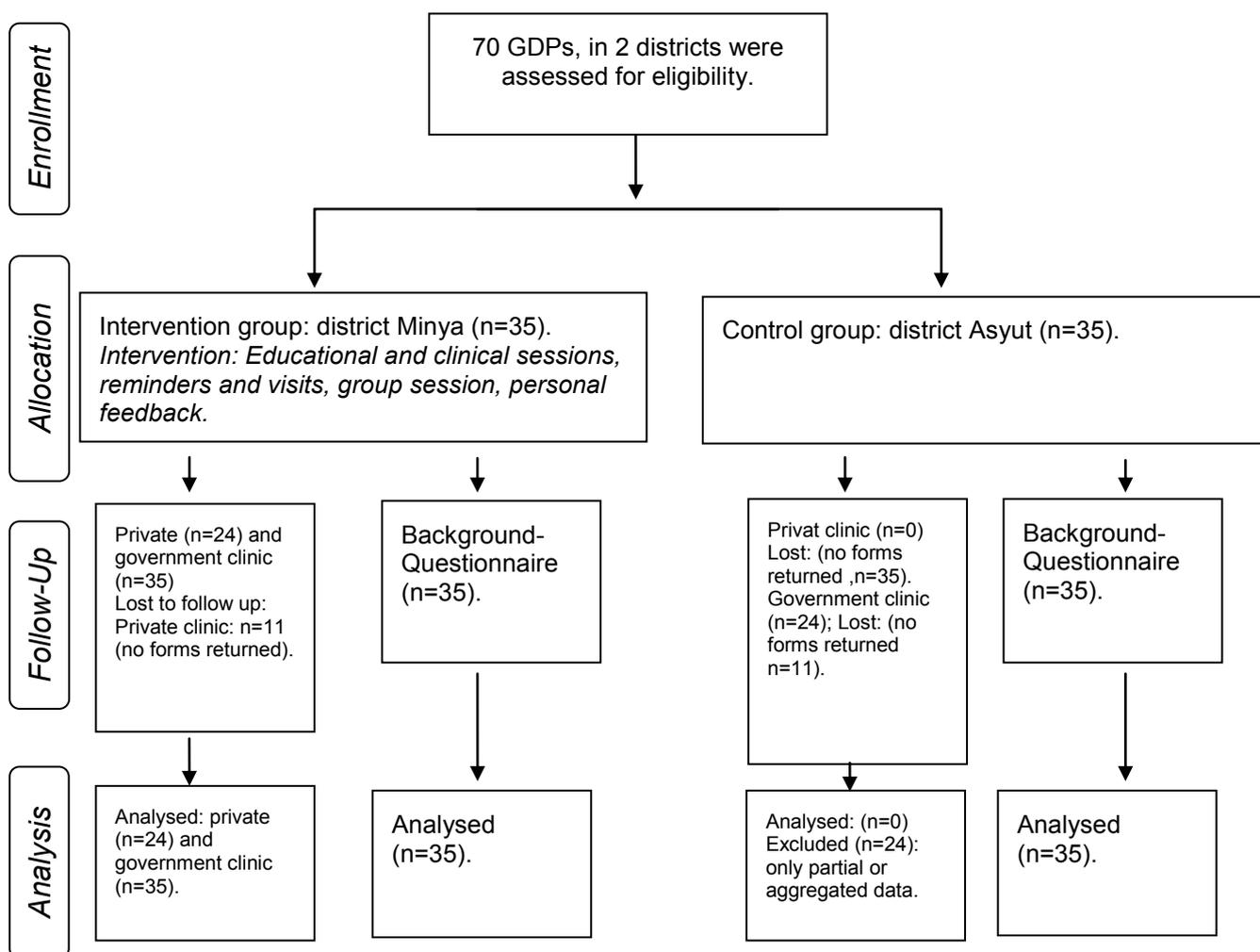
## **Sampling**

A pre-test - post-test control group study was designed. MOH presented a convenience sample of 70 Upper Egyptian GDPs, who were working in both private and governmental dental clinics. Eventually, the number of involved private clinics was 35 (out of a total of 164) in Minia governorate (test group), and 35 (out of a total of 195) in Asyut governorate (control group).

For governmental clinics, the numbers were 29 (out of a total of 248), and 24 (out of a total of 144), respectively.

Figure 6.1 shows the flow of the participants through the study.

**Figure 6.1.** Flowchart of the number of participants taking part in each stage of this study on the introduction of ART in Upper Egypt.



## Background questionnaire

The questionnaire comprised 42 items. Nine questions were on personal characteristics, 8 on clinical and continuing professional development and 15 on practice-related information. The remaining 10 questions were on clinical decision-making and are presented elsewhere (18).

Box 6.1. General information about Egypt, the health care system and the study governorates.

Egypt’s health care status is poor in comparison to the level of its national income. The health care system is complex and pluralistic. The Ministry of Health (MOH) is the major provider of care, which runs a nationwide system of health services. MOH services are provided largely free to all citizens. However, due to general long waiting times and insufficient equipment, most people will visit a private clinic. The second major provider is the Health Insurance organization (HIO), which provides universal coverage to the small urban formal sector.

*Oral health care*

A total of 28,000 general dental practitioners (GDPs) are working in the different health sectors. The majority of private dental clinics are located in the big cities in Lower Egypt. The dentist/population ratio in the rural areas, where almost 60% of the population lives, is consequently low. Due to the ‘Upper Egypt phenomena of poorness’, only a few dentists feel encouraged to work in this region. Oral care and dental hygiene is still not a major concern for many Egyptians, especially the uneducated middle- and low income population. Recent national epidemiological oral health data are not available.

*Information about Minya and Asyut Governorates.*

	Minya governorate	Asyut governorate
Total area:	32,280 km <sup>2</sup>	25,930 km <sup>2</sup>
Population:	4.2 million	3.5 million
MOH dental clinics (n):	248	144
Private dental clinics (n):	164	195
GDPs (n):	243	175

**Intervention group**

***Composition***

Inclusion criteria for participants were: willingness to attend the ART training course; knowledge of the English language; future employment for at least another year in a government dental clinic.

### ***ART training course***

The selected GDPs were trained in ART (19). In addition, topics on the caries process and prevention of enamel and dentine caries lesions, were covered. The training was given in an 8 hours per day 5-day workshop. A pre- and post-training questionnaire was used to test the effect of the training on the participants' knowledge.

### ***Evaluation and assessment***

Post intervention evaluation and assessments were done at 6 and 12 months, through use of questionnaires and clinical recording forms. Seven months after the training, a general reminder meeting for all course participants was organized. Twenty-four participants attended it.

### ***Assessment of GDPs' opinions and intentions to apply ART***

Another questionnaire was used for assessing GDPs' views about the application of ART. Four questions were used to assess the GDP's opinion on acceptability and suitability of ART application in government and private clinics in Upper Egypt. Intentions to apply ART in government and private clinics were assessed using five questions. The general opinion regarding ART was assessed by checking answers to open questions about its advantages and disadvantages.

### ***Assessment of expected and experienced barriers to introduction of ART***

A questionnaire with open questions on barriers related to ART introduction in government and private clinics in Upper Egypt was distributed during the training and after one year. In addition, after one year, each GDP's experience concerning ART was assessed from 10 statements.

### **Control group**

The control group comprised 35 GDPs working in government and private clinics in Asyut governorate, Upper Egypt. Background characteristics of the intervention group (gender, years of experience, weekly clinical working hours) were used in composing a comparable group.

All participants were asked to answer the questionnaire and fill in the clinical record forms.

### ***Clinical data collection in both groups***

Clinical data from government and private clinics were collected on a monthly basis, using clinical record forms. All GDPs were asked to complete these forms on a daily basis. Data on gender, age, tooth number, toothache, and type of treatment (prevention, restoration, or extraction) of patients were collected. For restoration cases Black's class type of cavity, tooth surfaces, material used (i.e., amalgam, resin composite, glass-ionomer, others), and preparation method (ART or conventional) were recorded.

Participants were asked to indicate the type of clinic (government or private) on each form. Non-respondents were reminded by telephone after one and two months.

## **Data analysis**

The total number of clinical activities done during the study was calculated for each participant per clinic. The answers to questions on opinion of the GDP on ART were dichotomized by combining 'strongly disagree' and 'disagree' into 'disagree', and 'strongly agree' and 'agree' into 'agree', while 'not applicable / not answered' remained unchanged. For each participant the answers to each question, pre- and post-training were coupled in a 2x2 table and McNemar's tests were done to test the change in opinion. The statistical significance was set at  $\alpha=0.05$ . The analyses were performed by a biostatistician using SAS version 9.2- software.

## **Results**

### ***Intervention group***

Thirty-five GDPs (11 females) attended the ART training. Twenty-six of them were younger than 30 years, while the ages of the rest ranged between 31 and 50. The mean length of practice experience was 9 years (range 1-23 yr.). All 35 GDPs

returned clinical data forms from their government clinic, and 25 of them did it also from their private clinics. In government clinics, the mean ratio of tooth extractions/restorations was 7:1 (range 1:1 to 40:1). A high work load, due to the number of patients needing urgent oral care, was reported by 58% of the participants.

### ***ART training***

At the end of the training, a statistically significant improvement ( $P < 0.001$ ) was found in responses to 18 (of 40) questions. These questions focused on the caries process, caries prevention and practical steps of ART application. No changes in knowledge were found for questions dealing with glass-ionomer material properties, dental sealants, and about the effects of patients' life style (e.g. tooth brushing, use of toothpaste) on oral health. Significantly more GDPs practiced ART after taking the course (Table 6.1).

### ***Assessment of GDPs' opinions and intentions to apply ART***

Table 1 shows an overview of participants' intentions and thoughts about ART at start and actual practice after one year. Thirty-one GDPs returned both questionnaires (response rate 89%). Most GDPs intended to introduce ART in their government and private clinics. After one year, significantly less GDPs actually introduced ART in their government clinic, compared to their intentions. Consequently, less GDPs actually made ART restorations in their governmental clinic.

**Table 6.1:** Intentions and attitudes concerning ART, of intervention group GDPs who returned both questionnaires (n=31), with p-values, at start and after 1 year.

Question / statement at start (A) and after 1year (B)	Agree		Disagree		P value
	Start N (%)	1year N (%)	Start N (%)	1year N (%)	
<b>Intention</b>					
- <sup>1</sup> A I already apply / B I have applied ART in my dental clinical work.	9 (33%)	26 (96%)	18 (66%)	1 (4%)	0.0001*
-A I intend to introduce / B I have introduced ART in my government clinic.	30 (97%)	22 (71%)	1 (3%)	9 (29%)	0.0047*
- A I intent to make / B I have made ART restorations in my government clinic <sup>3</sup> .	30 (97%)	20 <sup>3</sup> (65%)	1 (3%)	11 (35%)	0.0016*
- A I intend to introduce / B I have introduced ART approach in my private clinic?	27 (87%)	30 (97%)	4 (13%)	1 (1%)	n.s.
- A I intent to make/ B I have made ART restorations in my private clinic.	27 (87%)	30 (97%)	4 (4%)	1 (3%)	n.s.
<b>Attitudes</b>					
- ART approach is suitable for my government clinic. A / B	29 (94%)	28 (90%)	2 (6%)	3 (10%)	n.s.
- Patients in my government clinic A may accept / B have accepted ART restorations.	27 (87%)	18 <sup>2</sup> (90%)	4 (13%)	2 <sup>2</sup> (10%)	n.s.
- ART is suitable for my private clinic. A / B	26 (84%)	27 (87%)	5 (16%)	4 (13%)	n.s.
- Patients in my private clinic A may accept / B have accepted ART restorations.	26 (84%)	27 (97%)	5 (16%)	4 (13%)	n.s.

Statements: A: at start; B: after 1 year. \*: statistically significance  $p \leq 0.05$ ;

n.s. = no statistically significance; <sup>1</sup>: n=27 (4 non-respondents to this question); <sup>2</sup>:n=20, only respondents from Intention<sup>3</sup>.

### ***Expected and experienced barriers***

After 1 year experience, significantly more GDPs realized the simplicity of ART, whereas the other items on GDPs opinions about the advantages and disadvantages of ART remained stable (Table 6.2). There was a considerable increase in the number of the GDPs supporting the applicability of ART. The main barrier to application of ART in the government clinics was the unavailability of ART instruments and a suitable, high viscosity glass-ionomer restoration material. Twenty-one (68%) GDPs reported that there were no barriers to applying ART in their private clinics.

Table 6.3 covers the GDPs' general experiences related to ART. More than two-thirds of the participants had the opinion that the ART technique is, at least, equal to the conventional way of using mechanical devices to restoring teeth. Furthermore, more than half of the GDPs noted a positive attitude from government management, and felt that it supported adoption of ART in government clinics.

**Table 6.2:** Aspects mentioned mostly by GDPs (n=31) in the intervention group concerning advantages, disadvantages and barriers of introduction and using ART in government and private dental clinics, at start of study and after 1 year.

Opinion	At start (n)	After 1-year (n)	p-value
<b>Advantages:</b>			
Conservative / MID treatment	17	14	0.40
Simple technique	12	21	0.007
Applicable technique	3	9	0.06
Time effective procedure	7	8	0.76
Child friendly	6	8	0.56
No use of rotary instruments	5	8	0.26
No use of anesthesia	5	8	0.26
<b>Disadvantages:</b>			
Case selection	8	5	0.32
Material properties	6	8	0.42
Time consuming	4	7	0.26
<b>Barriers:</b>			
	<b>At Start</b>	<b>After 1-year</b>	
		<b>Government practice (n)</b>	<b>Private practice (n)</b>
Unavailability of suitable GIC	12	16	0
Unavailability of instruments	11	13	0
Patient acceptance	13	3	4
Financial costs	0	5	5
No barriers present	4	4	21

**Table 6.3:** Clinical experiences with, and opinions about ART technique after 1 year, of GDPs (n=24) in the intervention group.

Statement	Agree (n)	Disagree (n)	N.a.
Having experience with drilling as well as ART, it is generally better to restore teeth using drill than ART	6	17	1
I still have some doubts on the effectiveness of ART restorations.	8	16	
Overall, my patients like ART restorations	23	1	
Overall, I have adequate skills to make ART restorations.	24	0	
Overall, the fee for ART restoration is a barrier for the majority of patients.	6	18	
I have experienced some negative responses regarding ART from my superiors	5	15	4
Government management feels that glass ionomer is too expensive to afford.	7	14	3
The government management is pleased that I make ART restorations	13	3	8
Overall, my government administration fully supports ART	14	3	7

N.a. = not answered

### ***Clinical data***

On average, GDPs spend 16 hours (range 4-50) in their private, and 13 hours (range 8-20) in their government clinic, respectively, on restorative dentistry per week. Table 6.4 shows that almost 76% of the restorations were made in the private clinics and 24% in the government clinics. The number of ART restorations in government clinics halved during the second part of the study, compared to the first study part, whereas the numbers in private clinics remained stable. Black class 1 and class 2 restorations constituted both 35% of the total number of ART restorations made, while 11% were class 5 restorations. Another 10% concerned ART sealants.

**Table 6.4:** Number and types of restorations made by GDPs (n= 25) in the intervention group in their private and government practices during 1 year post test.

	<b>Number of restorations</b>		
	During March to November (%)	During November to March (%)	Total (%)
Private	1660 (40%)	1520 (36%)	3180 (76%)
Government	626 (15%)	369 (9%)	995 (24%)
<b>Restorative technique</b>			
Conventional	1437 (34%)	1032 (25%)	2469 (59%)
<i>Private clinic</i>	1008 (70%)	783 (76%)	1791 (73%)
<i>Government clinic</i>	429 (30%)	249 (24%)	678 (27%)
ART	849 (20%)	857 (21%)	1706 (41%)
<i>Private clinic</i>	612	737	1349 (79%)
<i>Government clinic</i>	237	120	357 (21%)
<b>Type of restorative materials</b>			
Amalgam	638	629	1267 (30%)
Composite	244	372	616 (15%)
Amalgam /composite	553	-	553 (13%)
GIC	788	857	1645 (40%)
Temporary filling material	61	33	94 (2%)
<b>Class of restorations</b>			
Class I	537	634	1171
<i>ART technique</i>	264	330	594
Class II	758	702	1460
<i>ART technique</i>	342	253	595
Class III	108	142	250
<i>ART technique</i>	51	51	102
Class IV	15	27	42
<i>ART technique</i>	3	2	5
Class V	127	132	259
<i>ART technique</i>	98	95	193
Sealants	84	96	180
<i>ART technique</i>	71	92	163
Not reported*	657	156	813
<i>ART technique</i>	20	34	54
<b>Gender</b>			
Male	1047	772	1819
Female	1099	919	2018
Not reported*	140	198	338

\* : The class of restoration or gender not reported.

### ***Control group***

All GDPs (n=35) returned the background questionnaire. Twenty GDPs returned (part of) their government clinical data, and 4 GDPs returned an overview with the total number of restorations and extractions, without any details. None of them returned the clinical record forms from their private clinic. Clinical data from this group could therefore not be analysed without accepting the potential inclusion of biased outcomes.

## **Discussion**

This study was planned as a pre-test post-test controlled trial. However, the GDPs in the control group did not return any clinical record forms from their private clinics and only partly returned those from their government clinics. This could be attributed to their cultural background, as these data are considered to be very private. In addition, they might not have seen any personal benefit. The bias in data from the control group prevented any reliable analysis, so this study should be seen as a cohort study, merely based on data from the intervention group. These aspects need more attention in future studies.

GDPs showed a positive attitude towards ART at start, and this contributed to a positive intention to apply a new procedure (20, 21). Almost all GDPs intended to introduce ART in their government clinic. However, because of the barriers that they met only a minority succeeded (Table 6.1).

MOH send 4 managers to attend the training course. The fact that they were allowed to attend the training, to gain familiarity with ART, indicated preliminary acceptance at government management level. This could have a positive effect on the barriers mentioned mostly (Table 6.2), as the management might now decide to provide their clinics with the essential ART materials and instruments. For those who want to introduce ART in comparable settings and countries, it can be recommended to start at management level, and then introduce it in government and routine dental practice. Meanwhile, in the private clinics almost all GDPs

applied ART, and the majority did not feel any barriers (Table 6.2). This indicates a high general acceptance and adoption of ART by GDPs.

The clinical data showed that almost 41% of the restorations placed were ART restorations. The increase in the number of ART restorations observed from the first to the second half year during the one-year post-training period further indicated the adoption of ART and the increased availability of materials in the private clinics. Further study is needed to determine whether this increase in ART restorations had indeed lowered the frequency of extractions.

ART is an evidence-based treatment for use in single-surface cavities but cannot routinely be used in multiple-surface cavities (9, 22). In this study, we found almost 35% of class II ART restorations (Table 6.4). In so far, more attention during the ART training should be paid on this topic, in order to prevent any possible disappointments regarding the survival of the ART restorations.

Because unavailability of pre-study data, we are uncertain if the ART restorations made during the first half of the follow-up period were due to the ART program. Nine participants mentioned to be already familiar with the ART technique. On the other hand, during the course, participants gained insight in, and got familiar with the required material, a high-viscosity glass-ionomer material, to make ART restorations, which was hardly obtainable before that time. In so far, one may presume that the program directly has influenced the number of ART restorations.

Only a quarter of the restorations were made in government clinics (Table 6.4). This could be explained by the absence of suitable ART restorative materials and ART instruments, and did not allow GDPs to actually introduce ART in the government setting. Some GDPs bought their own ART restoration material for use in their government clinic. However, this will not solve the problem at national level. Moreover, that Egyptian patients seek dental help only when experiencing severe pain, and that extraction is cheaper, might influence their treatment options. This situation has existed for decades (6).

The GDPs liked the simplicity of ART (Table 6.2) and thought that it would make treatment more comfortable to patients and lower their fear of restorative treatment, thus resulting in patients' seeking care in earlier stages of dental decay. In the near future, more teeth in Upper Egypt might be restored earlier, rather than removed in very late stages of caries progression.

In addition, after GDPs had practiced ART for one year, they realized the simplicity of this approach even more. This finding might have an important bearing to those who want to pioneer the introduction of ART in routine dental service. They should not despair when they find that many GDPs are hesitating to introduce ART at the beginning of the implementation program, as after GDPs have practiced ART, they are most likely to rejoice and like ART practice.

This study showed that GDPs in Upper Egypt have successfully introduced ART in their private clinics but not in their government dental clinics and that they liked the simplicity of the technique. GDPs faced barriers to implementation of ART in government clinics, despite of positive responses from the responsible management. This may indicate delays in government machinery to translate their willingness to support health innovations financially.

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## **CHAPTER 7**

### **Summary, general discussion and recommendations**

## **Abstract**

This thesis covers 5 studies related to introduction of the ART approach in the oral healthcare system of Egypt. In this chapter the main conclusions drawn from these studies are summarized and the implications of a nationwide introduction of ART in Egypt are discussed. Suggestions for future research and recommendations for organizational changes in the healthcare system conclude the chapter.

In **Chapter 1** the medical and particularly, the dental, infra-structure in Egypt is described. The country has a large public and private medical and dental service delivery sector which is centered in the Nile delta and along the river Nile. Upper Egypt is ill-served. Dentists working in the government health services, do additional dental work in a private clinic in the late afternoon and evening. Many of the government dental clinics are ill-equipped, so the delivery of oral health care services is very basic. The main treatment for a dental problem is extraction. Restorative materials are usually unavailable, as is rotary equipment, and when the equipment is available, it is usually not functioning.

Studies on the prevalence and severity of dental caries are relatively few and many were conducted decades ago. It was, therefore, difficult to execute a situation analysis regarding dental caries amongst the Egyptian population. A 2007 study covering adolescents in Cairo provided some information to go by. The caries prevalence, based on cavitated dentine lesions, was 38% and the mean DMFT score was 0.8. The prevalence of teeth restored and extracted was very low. However, the 2007 study, in essence, did not indicate a different situation from that identified by caries epidemiological studies carried out decades before. The caries situation in Egypt appears to be characterized by: 1) a high level of untreated cavitated carious lesions in the youth; 2) a high burden of untreated dental caries and its effects amongst the entire population, which may partly be ascribed to the absence of appropriate organized dental care in terms of dental personnel and dental facilities, as well as a low level of self-care amongst the population.

Introduction of the ART approach was thought to be a possible solution to the limitations in the delivery of oral care. This preventive and restorative caries management approach had been introduced in some countries: successfully (Mexico), relatively successfully (Tanzania) and not so successfully (South Africa and Cambodia). Successful introduction of ART appeared to be dependent on the steady availability of hand instruments and that of high-viscosity glass-ionomer in government dental clinics. The 2007-epidemiological survey amongst adolescents in Egypt concluded that the majority of cavitated dentine lesions without pulpal involvement could be treated using the ART approach. However, as with the

introduction of all new treatments, dentists in Egypt had to be convinced that ART could be a suitable treatment for use amongst members of the Egyptian population. The conclusion of **Chapter 1** lists the study objectives.

As few oral health studies about the delivery of oral health services in Egypt had been published, the introduction of ART into the health services in Upper Egypt was preceded by an investigation into the dentists' opinions about when and what kind of preventive and/or restorative treatment they thought necessary at various stages of a carious lesion development (**Chapter 2**). The assessment was done using a questionnaire which was presented to a convenient sample of 70 dentists in El Minya, the capital city of Upper Egypt, and Asyut governorate, who worked both in private and in public dental services. These dentists were also requested to keep track of the clinical dental procedures that they applied over one month, using a record form. The questionnaire was returned by all participants, while the record forms for clinic dental activities in government and in private services were returned by 59 (84%) and by 25 (36%) of the dentists, respectively.

Three types of dentists were arbitrarily identified as being: 'operative minded dentists' (those who provide many amalgam and resin composite restorations); 'problem solvers' (those who have many years of experience, see many patients and do very many temporary restorations); and 'thinkers' (those who spend many hours on expanding their professional development and make many restorations). Logistic regression analyses revealed only one statistically significant relation. They indicated that 'operative minded dentists' applied significantly fewer caries preventive measures than the other two groups of dentists. A total number of 45 (63%) participants had heard about ART and 13 (18%) practiced ART. Most patient visits to public dental clinics were pain-induced and the main treatment provided was extraction.

The investigation concluded that promotional, preventive and restorative care was rarely provided by private and public dental services and that the ART approach could partly improve the poor preventive and restorative care provided in Upper Egypt.

In order to further the process of getting the ART approach accepted among dentists in Upper Egypt, a clinical study was planned. This is described in **Chapter 3**. The null-hypothesis tested was that there is no difference between the survival of ART restorations with, and without, cavity disinfection among adolescents after 5 years. Eligible students were allocated to one of the treatment groups. One operator placed a total of 90 restorations, 45 each per treatment group, in ninety 14–15 year-olds. Restorations were evaluated on replica models at baseline and after 1 and 5 years, by two calibrated and independent evaluators using the ART restoration criteria. The independent variables were gender, mean DMFT score at baseline, cavity size (small/large), cavity type (single-/ multiple surfaces) and disinfected cavity (yes/no). Statistical analyses were done, using the Kaplan–Meier method and log-rank test. The cumulative survival percentage and standard error for the 90 ART restorations with and without disinfection at evaluation year 5 were 85% (SE=6.1%) and 80% (SE=7.1%), respectively: not significantly different from each other. The cumulative survival percentage and standard error for all ART restorations was 97% (SE=2.0%) at evaluation year 1 and 82% (SE=4.7%) at year 5, and it was 85% (SE=5.4%) for single- and 77% (SE=9%) for multiple-surface ART restorations at year 5. The cumulative survival percentage of all ART restorations at evaluation year 5 was statistically significantly higher for boys than for girls.

It was concluded that disinfecting a cavity cleaned according to ART with a 2% chlorhexidine solution was unnecessary and that systematic introduction of the ART approach into the healthcare system in Egypt would be useful.

During the course of the clinical study, a new set of criteria for assessing the quality of restorations using modern restorative materials, named FDI criteria, was introduced. As an impression had been taken from all ART restorations at baseline, after 1 and after 5 years, the decision to assess the ART restorations, using the newly launched FDI and the ART restoration criteria, was made (**Chapter 4**). This study tested the null hypothesis that there is no significant difference in survival percentages of ART restorations assessed according to selected FDI and modified ART restoration criteria after 1 and 5 years. One operator placed a total of 60 class I and 30 Class II high-viscosity glass-ionomer

ART restorations. Two calibrated and independent evaluators using both sets of criteria evaluated restorations on diestone replicas at baseline and after 1 and 5 years. Statistical analyses were done using the Kaplan–Meier method and log-rank test. The survival results of ART restorations assessed in accordance with both sets of criteria after 1 and 5 years did not differ significantly. Three ART restorations were assessed as failures according to the modified ART restoration criteria, while they were assessed as ‘survived’ according to the selected FDI criteria. It was concluded that the modified ART restoration criteria enabled reliable assessment of ART restorations in permanent teeth from diestone replicas and that there was no significant difference in survival estimates of ART restorations assessed against both sets of criteria.

Information on the ART approach, that would facilitate its introduction into the oral health service delivery system in Upper Egypt further, was thought to be related to one of the advantages of ART; its apparent reduced level of discomfort in relation to the traditional restorative approach. Therefore, the clinical study included a questionnaire that assessed the levels of acceptance and discomfort experienced by secondary school students when undergoing an atraumatic restorative treatment (ART) procedure (**Chapter 5**). Immediately after completion of their restoration each of the 90 students was asked about the level of sensation experienced during cavity preparation. Prior to that, the depth of the cavities was judged clinically and from radiographs as; into outer, middle and inner 1/3 of dentine. Using a graded periodontal probe, the cavity size was measured as extending into approximately half the width of the mesio-distal and bucco-lingual/palatinal distance of the occlusal surface. Of the 90 students, 6 (6.6%) experienced pain and 26 (29.2%) experienced discomfort during cavity preparation. This occurred more often in large than in small cavities, and more often in cavities extending into the inner 1/3 than in those in the middle and outer 1/3 of dentine. Only one student reported post-operative sensitivity.

This aspect of the clinical study showed that the ART approach was well accepted by this group of secondary school students as a treatment for dental cavities. Only a few reported pain during cavity excavation, and this was more prevalent in large cavities and in cavities with the floor close to the pulp.

On the basis of the results of the clinical study and the wish of dentists in Upper Egypt to carry out promotional, preventive and restorative oral health treatments, plans were made to introduce the ART approach into private and public oral healthcare services in the Minya region of Upper Egypt (**Chapter 6**). The first step of this introductory process was delivery of a 5-day ART training course that included information on caries preventive measures. The plans also catered for an evaluation of the effectiveness of the training course in stimulating the participating dentists to actually apply ART sealants and ART restorations as well as other necessary caries-preventive measures.

A total of 35 GDPs participated in the ART training course. All were employed by government in the public health services and managed a private clinic in the afternoon/evening hours. Their knowledge about caries prevention and the ART approach was assessed immediately before and after the training course, using a structured questionnaire. Regular evaluation and assessment data were collected after 6 and 12 months via questionnaires with closed and open-ended questions. Clinical data from government and private clinics were collected, using a record form.

The GDPs' opinions and intentions regarding expected and perceived barriers affecting the introduction of ART were assessed, using a questionnaire, at the start of the study and after one year. The analyses showed that the majority of GDPs intended to make ART restorations at the start, but not all succeeded in doing so. In government dental clinics only 65% of dentists made at least one ART restoration during the one-year observation period. In private clinics, the proportion of dentists placing ART restorations was very high (97%).

The barriers that GDPs faced in producing ART restorations in the government dental clinics were mainly related to the unavailability of the restorative material used with ART (52%) and the poor state of the hand instruments (42%). After 1 year, ART restorations constituted 41% of the total restorations done in private and government dental clinics. Finally, 93.5% and 83.9% of the GDPs believe that ART is a suitable caries management approach for use in government dental clinics and private practice, respectively.

It is concluded that the introduction of the ART approach in Upper Egypt into the government dental clinics was hampered by the unavailability of suitable hand instruments and of suitable restorative materials. These barrier factors were not present in the dentists' private practices, which facilitated the placement of ART restorations. This resulted in a substantial increase in restored teeth that otherwise would have been extracted during the one-year observation period.

## **General Discussion**

### ***Methodological aspects***

Clinical data from private and government dental clinics were exclusively collected through use of record forms (Chapter 6). Other data sources, such as medical record reviews and health insurance company databases were used for measuring clinical performance in a primary medical care setting (1). The most significant advantage of clinical case-recording is the increased yield of data, resulting in a more complete clinical decision review (1). It appears that the clinical case recording study, described in Chapter 6, is the first large prospective study in Egypt that has obtained information about the characteristics and frequency of dental restorations placed in government and private dental clinics. The intention was to gain a better insight into the clinical practice patterns (behaviour) of GDPs, in the absence of reliable epidemiological data. However, the control group returned only a small number of the clinical record forms from government dental clinics and none from the private clinics. In contrast, almost all participants in the intervention group returned the forms (Chapter 6). The low response from participants in the control group has affected the findings of the study seriously and reduced the validity of the study results obtained. The study design was explained to participants in the intervention group, whereas those in the control group did not receive any information on this topic. This may be one of the reasons for the difference in the behaviour of participants in the control and the intervention group, regarding the return of record forms. Another explanation may relate to the cultural background of participants, as such data are considered by them to be very private. Some participants, especially in the control group, may

have feared that the data might be misused by others. Insight into the methodology and use of randomized controlled trials, in combination with acceptance of the researchers' promise that all data would be used confidentially and anonymously, might have resulted in a higher response rate for the intervention group.

That a recent search in PubMed, using the following MeSH terms 'randomized controlled trial', 'oral health', 'Egypt' and 'English or Arabic language' did not reveal any new findings suggests that most Egyptian GDPs may still be rather unfamiliar with this kind of research design.

It is apparent that in future studies, especially randomized controlled trials, all aspects of the study design and their importance should be explained to all participants, in order to ensure collection of reliable data. Another way of increasing dentists' knowledge related to research is to enhance the number of undergraduate teaching hours allocated to scientific education, research methodology and training in evidence-based clinical decision-making.

### ***General Findings***

Assessment of strategies applied for caries control indicated that most GDPs in Upper Egypt have an operative-minded treatment philosophy and therefore, do not frequently use caries-preventive measures. The main treatment provided in the clinics is the removal of badly decayed teeth. Amalgam is the material most commonly used in the restoration of decayed teeth (Chapter 2). This finding corroborates the results from an epidemiological study in the late eighties in Egypt (2) and those covering other African countries (3). The indication is that preventive dentistry and minimal operative intervention strategies are still rare within the Egyptian oral health care system. Although there are some essential differences, Egypt and other African countries share many common factors. Introduction of the ART approach in countries such as South Africa (4), Tanzania (3) has shown that an uninterrupted availability of quality hand instruments and quality high-viscosity glass-ionomers is necessary for the successful introduction of ART. A further requirement is a well-structured ART training course that includes days of clinical practice.

The main focus of the ART approach is on the prevention of oral disease. As most of the GDPs in Upper Egypt were shown to have an operative-minded treatment philosophy, introduction of the ART approach in their country should be combined with intensive continuing professional education courses on oral disease prevention. In addition, courses on modern evidence-based care approaches, such as minimal intervention dentistry (MID), might broaden the range of GDPs' options for managing oral diseases. Educating the dental profession should be combined with educating the population in Upper Egypt about the importance of good oral health. This would best be achieved through a local or national program based on promoting good oral health through daily oral hygiene and diet control, in combination with advice about tooth-friendly life styles. This would facilitate the achievement of a future improvement of the oral health of the people in Upper Egypt.

The level of patients' acceptance of dental care depends to a great extent on the sensitivity and pain experienced during treatment (8). The ART approach was new to high school students in Upper Egypt. They accepted it well and only a few students reported pain during treatment (Chapter 3). Patients' acceptance of a new treatment modality greatly affects the adoption and establishment of this new treatment on a nationwide level. It is likely that the reduction in the levels of pain and dental anxiety, related to the use of ART, may facilitate a smooth acceptance of the ART approach in Upper Egypt (Chapter 3). It is hoped that ART will contribute to an improved attitude in patients needing dental therapy, allowing management of carious lesions to take place earlier and thus increasing the chance of saving many teeth from extraction. Studies in other countries have shown the positive impact of the ART approach on dental anxiety and pain experience (9).

The survival of ART restorations in single- and multiple-surface restorations observed in the present study was high (Chapter 4). The findings fall within the annual failure rate of these type of restorations as reported in the meta-analyses on ART restorations and ART sealants of early 2010 (10). These positive findings

support the need for discussion related to a nationwide introduction of the ART approach in Egypt.

In 2007 the Science Committee of the FDI World Dental Federation recommended use of the new FDI criteria for the evaluation of restorations in clinical investigations of restorative materials and/or operative techniques (11, 12). It was thought necessary to investigate the extent to which this new set of criteria differs in practice from the modified ART criteria. Results described in Chapter 5 show no significant differences in the survival estimates of ART restorations when assessed in accordance with both sets of criteria.

The modified ART criteria are far less detailed and include far fewer clinical restoration characteristics than the FDI criteria but are easier and faster to use (Chapter 5). The ART criteria consider a restoration a failure if code 2 ('restoration is present, but has a deficiency at the cavity margin of 0.5 mm or more') is scored. This might result in an overestimation of the failure rate of (ART) restorations, as a code 2 in many cases reflects a restoration that is still functional, without any signs of carious lesion activity.

Chapter 5 provides three examples in which a restoration was regarded as 'failed' according to the ART criteria, but not according to the FDI criteria.

As the ART approach was originally developed for use in low- and middle-income countries and underserved communities, and for easy comparison of results between studies from different countries, detailed scoring of restoration characteristics, as is the aim of the present restoration (USPHS) criteria, was thought to be unnecessary.

The intention behind the ART criteria was to assess the long-term functionality of ART sealants and ART restorations. Thus, the presence of a functional, dentine carious lesion free tooth is the most important criterion. This aspect might have been overlooked during the development and description of the first and modified ART criteria, as these are mainly based on assessing a restoration that replaces lost tooth tissues and morphology in all its aspects.

The ART criteria need to be reformulated and in this process the above-mentioned aspect as well as the redefinition of code 2 should be considered. An evidence-based consensus method, like the RAND Delphi method (13, 14), could be used in formulating an international redefinition of, at least, ART codes 2 and 3.

Introduction of the ART approach in Upper Egypt may interrupt the vicious cycle of pain, discomfort and eventual tooth loss resulting from untreated dentin cavities. In combination with a nationwide preventive program of oral health care, the introduction of ART could also in the long term result in improvement of the oral health status of the population in Upper Egypt.

## **Conclusions**

- Most GDPs in Upper Egypt have an operative-minded treatment philosophy, and spend little time on preventive measures. Tooth extraction is the treatment most frequently provided. Amalgam is the restorative material commonly used (Chapter 2).
- The ART approach to treating dental cavities has been accepted well by a group of secondary school students (Chapter 3).
- Disinfecting, with a 2%chlorhexidine solution, a cavity that has been cleaned according to the ART procedure is unnecessary and has no positive influence on the longevity of the restoration over a period of 5 years (Chapter 4).
- The modified ART criteria enabled reliable assessment of ART restorations in permanent teeth, from die-stone replicas (Chapter 5).
- GDPs who attended an ART course successfully introduced ART in their private clinic but could not do so in government dental clinics (Chapter 6).
- Successful introduction of ART in government clinics in Upper Egypt requires the availability of suitable hand instruments and quality restorative material (Chapter 6).
- GDPs in Egypt liked the simplicity of the ART technique (Chapter 6).

## Recommendations

1. A preventive program for enhancing oral health in Egypt should be developed.
2. The ART approach should be implemented in the oral healthcare system of Upper Egypt.
3. The Ministry of Health, Dental Department, should offer ART training courses to dentists in government dental clinics.
4. Government clinics should be provided with suitable hand instruments and high-viscosity glass-ionomer, to facilitate the placement of ART sealants and ART restorations.
5. Further research on the longevity of ART restorations in several age groups of the Egyptian population is necessary.
6. The modified ART criteria need to be redefined.

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## **Chapter 8**

### **Samenvatting, Conclusies en Aanbevelingen**

## Samenvatting

Dit proefschrift is gebaseerd op 5 studies die handelen over de introductie van de ART techniek in de mondzorg in Egypte. Deze samenvatting geeft een overzicht van de belangrijkste conclusies van de individuele studies. Daarnaast worden de resultaten en aanbevelingen gepresenteerd.

In **Hoofdstuk 1** wordt de medische, en in het bijzonder de tandheelkundige, infrastructuur in Egypte beschreven. Het land heeft een uitgebreide medische en tandheelkundige sector, zowel privé als door de overheid gefinancierd. Deze is evenwel vooral geconcentreerd in Beneden – Egypte: het deltagebied van en langs de Nijl. Boven – Egypte, het gebied ten zuiden van Caïro, is daarentegen slechter toebedeeld. Tandartsen werken overdag in door de overheid betaalde klinieken en in de namiddag en avonden in een privépraktijk. Vele overheidsklinieken zijn slecht uitgerust, zodat de geleverde tandheelkundige zorg daar erg elementair van aard is. De meest toegepaste behandeling van een tandheelkundig probleem in een overheidskliniek is extractie. Tandheelkundige restauratieve materialen zijn meestal niet beschikbaar, evenmin als tandheelkundige apparatuur. Zijn deze wel aanwezig, dan functioneren ze meestal niet naar behoren.

Er is weinig epidemiologisch onderzoek gedaan naar de aanwezigheid en ernst van tandcariës in Egypte, en de wel beschikbare cijfers zijn gedateerd. Het was daarom niet gemakkelijk om een analyse te verrichten van de prevalentie van cariës onder de Egyptische bevolking. Een studie uit 2007, onder jongeren in Cairo, rapporteert een cariësprevalentie van 38 %, gebaseerd op gecaviteerde dentine laesies, en een gemiddelde DMFT score van 0.8. Het aantal gerestaureerde en geëxtraheerde elementen was erg laag. De uitkomsten van deze studie verschillen weinig met die van eerdere studies. Er leek in Egypte sprake te zijn van: 1) een hoge graad van onbehandelde cariës bij jongeren en 2) een hoge graad van onbehandelde cariës en de gevolgen hiervan bij de gehele bevolking. Dit werd mede veroorzaakt door zowel een slechte infrastructuur,

gebrek aan personeel en faciliteiten, als een slechte mondhygiëne bij de bevolking.

De introductie van ART werd gezien als een mogelijkheid om de beperkte tandheelkundige zorg te verbeteren. ART was al geïntroduceerd in een aantal landen: met succes in Mexico, redelijk succes in Tanzania en met minder succes in Zuid-Afrika en Cambodja. Hierbij leek de mate van succes afhankelijk te zijn van de constante beschikbaarheid van handinstrumenten en hoogviskeuze glasionomeer in overheidsklinieken. De conclusie van de hierboven genoemde studie in Cairo uit 2007 onder jongeren was dat het merendeel van de gecaviteerde dentine laesies zonder pulpa schade, behandeld had kunnen worden met ART. Echter, zoals met de introductie van alle nieuwe behandelmethoden het geval is, moesten de tandartsen in Egypte er eerst van overtuigd worden dat ART een geschikte behandeling zou kunnen zijn voor de Egyptische bevolking. De conclusie van **Hoofdstuk 1** geeft een overzicht van de doelstellingen van de studie.

Aangezien er weinig studies waren gepubliceerd over de tandheelkundige zorg in Egypte, werd de introductie van ART in Boven – Egypte voorafgegaan door een onderzoek naar de opinies van tandartsen ten aanzien van noodzakelijke preventieve en/of restauratieve behandelingen bij de diverse stadia van cariës. De resultaten van dit onderzoek staan beschreven in **Hoofdstuk 2**. Geselecteerd middels een gelegenheidssteekproef, werden 70 tandartsen, werkzaam in zowel een privépraktijk als een overheidskliniek in de Boven-Egyptische provincies Minya en Asyut, gevraagd een vragenlijst in te vullen. Hier was de respons 100 %. Verder werd aan deze tandartsen gevraagd om een maand lang op een rapportageformulier te noteren welke tandheelkundige procedures ze toepasten. Hier was de respons 84 % in de overheidsklinieken en 25 % in de privépraktijken. Er konden drie types tandartsen geïdentificeerd worden: ‘interventie gerichte’ tandartsen (die vele tandheelkundige amalgaam en composiet restauraties maakten), ‘probleem oplossers’ (die vele jaren ervaring hadden, vele patiënten zagen en vele tijdelijke restauraties maakten) en ‘denkers’ (die vele uren besteedden aan hun persoonlijke professionele ontwikkeling en vele restauraties verrichtten).

Uit de regressie analyse kwam slechts één statistisch relevante relatie naar voren: 'interventie gerichte' tandartsen pasten significant minder cariëspreventieve maatregelen toe dan de andere twee groepen. Verder bleek dat 45 (63 %) van de deelnemende tandartsen van ART gehoord hadden en 13 (18 %) ART al toepasten. De meeste patiënten die naar de overheidsklinieken kwamen, deden dit vanwege pijnklachten en de meest toegepaste behandeling was extractie.

De conclusie van het onderzoek was dat voorlichting, preventieve en restauratieve zorg nauwelijks werden aangeboden in de privépraktijken noch in de overheidsklinieken. De introductie van ART zou de preventieve en restauratieve mondzorg in Boven - Egypte gedeeltelijk kunnen verbeteren.

In **Hoofdstuk 3** worden de resultaten beschreven van een klinische studie, die als doel had ART bekender te maken en daardoor beter geaccepteerd te krijgen. De getoetste nulhypothese was dat er na 5 jaar geen verschil te constateren zou zijn tussen de overleving van ART restauraties met of zonder desinfectie met chloorhexidine van de caviteit. Voor de studie geschikte leerlingen werden toegewezen aan een behandeling met of zonder desinfectie. Een en dezelfde tandarts plaatste in totaal 90 restauraties, 45 bij elke groep, bij totaal 90 jeugdigen (14-15 jarigen). De restauraties werden middels tandheelkundige gipsmodellen, gemaakt bij het begin van de studie (de baseline), na 1 en na 5 jaar, geëvalueerd aan de hand van de ART restauratie criteria door twee gekalibreerde en onafhankelijke beoordelaars. Het overlevingspercentage en de standaarddeviatie voor de ART restauraties met of zonder desinfectie na 5 jaar was 85 % (SD = 6.1%) en 80% (SD = 7.1 %), en derhalve niet significant verschillend. Het overlevingspercentage en de standaarddeviatie voor alle ART restauraties was 97 % (SD = 2 %) na 1 jaar en 82% (SD = 4.7 %) na 5 jaar, en 85 % (SD = 5.4 %) voor éénvlaks- en 77 % (SD = 9 %) voor meervlaks - ART restauraties na 5 jaar. Het overlevingspercentage van alle ART restauraties na 5 jaar was statistisch significant hoger voor jongens dan voor meisjes. De conclusie was dat desinfectie van een caviteit volgens ART criteria met een 2% chloorhexidine oplossing niet noodzakelijk is, en dat de introductie van ART in Egypte nuttig zou kunnen zijn.

Gedurende de klinische studie werden door de FDI nieuwe criteria geïntroduceerd om de kwaliteit van restauraties met moderne restauratieve materialen te

beoordelen. Omdat er modellen waren gemaakt van alle ART restauraties bij de start van de studie (de baseline), na 1 en na 5 jaar, werd besloten bij de beoordeling van de ART restauraties zowel de ART criteria als deze nieuwe FDI criteria toe te passen. De resultaten hiervan staan beschreven in **Hoofdstuk 4**. Deze studie toetste de nulhypothese dat er geen significant verschil is in de overlevingspercentages van ART restauraties, geëvalueerd volgens de ART criteria en de nieuwe FDI criteria, na 1 en 5 jaar. Er werd gebruik gemaakt van dezelfde gipsmodellen als beschreven in hoofdstuk 3. Twee gekalibreerde en onafhankelijke beoordelaars beoordeelden aan de hand van beide sets criteria de restauraties op basis van modellen bij het begin van de studie (baseline), na 1 en na 5 jaar. Deze beoordelingen verschilden niet significant van elkaar. Drie ART restauraties werden als 'mislukt' beoordeeld volgens de ART criteria, terwijl ze als 'voldoende' werden beoordeeld volgens de FDI criteria. De conclusie was dat de ART criteria een betrouwbare beoordeling van ART restauraties aan de hand van gipsmodellen mogelijk maken. Verder is er geen significant verschil geconstateerd in de beoordeling van de overleving van ART restauraties volgens beide sets criteria.

Gedacht werd dat informatie over één van de voordelen van ART ten opzichte van de traditionele restauratieve methode, namelijk minder last en pijn, de introductie van ART in Boven – Egypte zou vergemakkelijken. Daarom bestond de klinische studie bij leerlingen die een ART restauratie kregen, ook uit een vragenlijst naar de mate van acceptatie en de ervaren last. De resultaten staan beschreven in **Hoofdstuk 5**. Direct na de restauratieve behandeling werden alle 90 leerlingen gevraagd naar de mate van gevoeligheid en pijn gedurende de preparatie van de caviteit. Daaraan voorafgaand werd de diepte van de caviteit vastgesteld, klinisch en via een peri-apicale röntgenopname: de buitenste 1/3, de middelste 1/3 en de binnenste 1/3 van het dentine. Van de 90 leerlingen hadden 6 (6.6 %) last van pijn en 26 (29.2 %) ervoeren ongemak tijdens de preparatie van de caviteit. Dit was vaker het geval bij grote dan bij kleine caviteiten en vaker bij caviteiten die zich uitbreidden tot de binnenste 1/3 dan de middelste 1/3 of buitenste 1/3 van het dentine. Slechts één leerling rapporteerde gevoeligheid na de behandeling. Het bleek dat ART als behandeling van carieuze caviteiten goed ontvangen werd door de leerlingen. Slechts een paar rapporteerden pijn gedurende de excavatie, en dit

meer bij grote caviteiten en bij caviteiten waarbij de preparatiebodem reikte tot dicht bij de pulpa.

Op basis van de resultaten van de klinische studie en de wens van de tandartsen in Boven - Egypte om voorlichting, preventieve en restauratieve behandelingen te geven, werden plannen gemaakt om ART te introduceren in privépraktijken en overheidsklinieken in de regio Minya. De wijze waarop dit gedaan werd en de resultaten hiervan staan beschreven in **Hoofdstuk 6**. De eerste stap in dit traject was het verzorgen van een 5-daagse ART trainingscursus, die ook informatie bevatte over preventie van mondziekten. Tevens werd de effectiviteit van de trainingscursus om de deelnemende tandartsen te stimuleren om ART sealants en restauraties toe te passen als ook andere noodzakelijke cariës preventieve maatregelen, geëvalueerd. In totaal 35 tandartsen volgden de cursus, allen werkzaam in zowel een overheidskliniek als een privépraktijk. Hun kennis van cariëspreventie en ART werd gemeten direct voor en na de cursus via een gestructureerde vragenlijst. Evaluatie- en beoordelingsdata werden verzameld via vragenlijsten met open en gesloten vragen na 6 en 12 maanden. Klinische gegevens van de overheidsklinieken en privépraktijken werden verzameld via een rapportageformulier. De opinies en intenties van de tandartsen ten opzichte van verwachte en ervaren barrières betreffende de introductie van ART werden gemeten via een vragenlijst, bij de start van de studie en na 1 jaar.

De analyses lieten zien dat de meerderheid van de tandartsen bij het begin van plan waren om ART restauraties te gaan toepassen, maar het uiteindelijk niet deden in de overheidskliniek. In de overheidsklinieken maakte slechts 65 % van de tandartsen minstens 1 ART restauratie gedurende de 1 jaar durende observatieperiode. In de privépraktijken was het aantal tandartsen die ART toepasten heel hoog (97 %). De barrières die de tandartsen tegenkwamen in de overheidsklinieken waren vooral gerelateerd aan het niet beschikbaar zijn van ART restauratieve materialen -een hoog-visceus glasionomeer restauratiemateriaal- (52%) en de slechte toestand van de handinstrumenten (42%). Na 1 jaar bestonden 41% van de totale restauraties in privépraktijken en overheidsklinieken uit ART restauraties. Een aandeel van bijna 94% en 84% van de tandartsen in respectievelijk de overheidsklinieken en de privépraktijken was van mening dat ART een geschikte methode is om cariës te behandelen.

Geconcludeerd kan worden dat de intentie van de studie om ART te introduceren in Boven – Egypte, in de overheidsklinieken bemoeilijkt werd door het gebrek aan geschikte handinstrumenten en restauratieve materialen. In de privépraktijken deden deze barrières zich niet voor, wat het plaatsen van ART restauraties vergemakkelijkte. Dit resulteerde gedurende de observatieperiode van 1 jaar, in een substantiële toename van het aantal gerestaureerde elementen die anders mogelijk zouden zijn verwijderd.

## **Conclusies**

Gebaseerd op de uitkomsten van dit promotie onderzoek, worden de volgende conclusies getrokken:

- Het merendeel van de tandartsen in Boven-Egypte hebben een op een curatieve interventie gerichte behandelaanpak, en bieden veel minder aandacht aan een preventieve aanpak. Het verwijderen van gebitselementen is de meest uitgevoerde behandeling. Voor het merendeel van tandheekkundige directe restauraties wordt amalgaam als restauratiemateriaal gebruikt (Hoofdstuk 2).
- De ART methode voor het behandelen van hun dentale laesies werd door een groep scholieren goed geaccepteerd (Hoofdstuk 3).
- Het desinfecteren met een 2% chloorhexidine oplossing van een dentale caviteit, die via de ART methode is geprepareerd, is onnodig en heeft geen positieve invloed op de 5-jaars overleving van de restauratie (Hoofdstuk 4).
- De ART criteria leveren betrouwbare resultaten op bij het beoordelen op gipsmodellen van - via de ART methode gemaakte – tandheekkundige restauraties in blijvende elementen (Hoofdstuk 5).
- De tandartsen die deelnamen aan de ART cursus pasten daarna de ART aanpak in hun eigen praktijk toe, maar konden de ART aanpak niet toepassen in de overheidskliniek (Hoofdstuk 6).
- Om de invoering van de ART methode in de tandheekkundige overheidskliniek in Egypte te laten slagen, vormen de beschikbaarheid van

zowel goed handinstrumentarium alsook een geschikt restauratiemateriaal essentiële voorwaarden (Hoofdstuk 6).

- Tandartsen in Egypte waardeerden de eenvoud van de ART methode (Hoofdstuk 6).

## **Aanbevelingen**

Gebaseerd op de uitkomsten van dit promotie onderzoek, worden de volgende aanbevelingen gedaan:

- Het verdient aanbeveling om een voor het bevorderen van de mondgezondheid in Egypte een preventief programma te ontwikkelen.
- De ART methode zou in het mondzorg systeem in Egypte dienen te worden geïmplementeerd.
- De Egyptische overheid, met name de minister van volksgezondheid, zou tandartsen die werkzaam zijn in tandheelkundige overheidsklinieken het volgen van een ART cursus moeten aanbieden.
- Tandheelkundige overheidsklinieken zouden bevoorraad moeten worden met voldoende geschikte ART handinstrumenten en een hoog-visceus glasionomeer restauratiemateriaal, om daar - via de ART methode - tandheelkundige verzegelingen en restauraties te kunnen maken.
- Verder onderzoek naar de daadwerkelijke levensduur van ART restauraties in de verschillende leeftijdscategorieën van de Egyptische populatie is noodzakelijk.
- De ART criteria dienen nog verder te worden verfijnd.

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