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Clinical Evaluation of Mandibular Overdentures Supported by Multiple-Bar Fabrication: 
A Follow-up Study of Two Implant Systems

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A retrospective follow-up study was undertaken to assess the clinical condition, complications, and prosthodontic aftercare of two different implant systems over a long period. Thirty-six patients treated with a total of 135 ITI type F endosseous implants, and 37 patients treated with the transmandibular implants and a total of 146 transmandibular posts, were studied during a mean follow-up period of 70 months and 44 months, respectively. The choice of implant type was mainly influenced by a change in financial support by the National Health Insurance Company in The Netherlands in 1987. Cumulative success rates were calculated using the Kaplan-Meier product limit method. In the analysis, the risk for failure of the implants was adjusted for differences in mandibular bone height. There were no differences between the two treatment groups with regard to age, gender, period of edentulousness, and mandibular bone height. During the follow-up period, plaque, bleeding, and hyperplasia scores demonstrated no significant differences between the two groups. The ITI type F group showed significantly more recession, and the transmandibular implant group demonstrated significantly increased Periotest values. After adjusting for differences in bone height, patients treated with ITI type F implants had a lower risk of failure (relative risk, 0.55; 95% confidence interval 0.32 to 0.95). However, neither of the implant systems fulfilled Albrektsson's criteria of success.


Key words: follow-up, implant, overdenture, superstructure

Bränemark and coworkers1-4 have shown that implants can serve successfully as anchorage for a fixed prosthesis in the edentulous mandible. During the last decade, clinical experience with mandibular overdentures supported by implants has increased,5-9 but few articles discuss the number and location of the implants, design options of retention systems, or choice of implant type.

In The Netherlands, with its large population of edentulous adults (25.0%) compared to other countries (9.5% to 25.0%),10,11 the implant-supported mandibular overdenture has become the treatment of choice for edentulous patients with persistent problems associated with wearing a conventional denture. From 1983 to 1990, two implant systems were used for this method of treatment in hospitals in The Netherlands, the ITI type F endosseous implant (Institute Straumann, Waldenburg, Switzerland)12 and the transmandibular implant (TMI, Krijnen Medical BV, Beesd, The Netherlands).13 Both types of implants are useful for providing retention and support for the mandibular denture and are preferably used with a bar-type superstructure. The clinical
results of several studies concerning these implant types have been published. Although the survival rates of the two systems appear to be similar, information regarding the quality of survival is limited.

During the period 1983 to 1990, the choice of implant type in hospitals in Zwolle, The Netherlands, was largely influenced by National Health Insurance, which supported the ITI type F implant from 1983 to 1987, and the TMI from 1987 to 1990. This enabled the assessment of the clinical condition, complications, and prosthetic aftercare of two different implant systems in two patient groups.

Materials and Methods

All patients receiving either an ITI type F or a TMI implant between January 1983 and December 1990 at the Department of Oral and Maxillofacial Surgery and the Department of Maxillofacial Prosthodontics at De Weezenlanden and Sophia Hospitals, Zwolle, The Netherlands, were selected for the present study. However, because ITI implants cannot be used in patients with bone height less than 7.5 mm, and the TMI has not been used in patients with mandibular bone height greater than 16.0 mm, patients with bone heights beyond these limits were excluded. From 1983 to 1987, the hospitals were allowed to use only the ITI type F system. From 1987 to 1989, only transmandibular systems were supported by the National Health Insurance Company (since 1989, any system can be used).

A preoperative orthopantomograph and cephalometric radiographs were obtained for each patient. Bone height was measured on the orthopantomograph medial to the last implant, both left and right. Original heights were derived from the length of the placed implants. Values of the right and left measurements were averaged.

Placement of ITI type F implants requires a one-stage intraoral procedure under local anesthesia. The TMI is placed using an extraoral approach under general anesthesia. The surgical procedure was performed by one surgeon following described protocols. All patients received antibiotics (375 mg of amoxicillin three times a day) at the time of surgery. When necessary, soft tissue surgery was carried out to create a sufficient width of attached mucosa. Patients were instructed to rinse with chlorhexidine 0.1% for the first 2 weeks after surgery. Frequent oral hygiene checks were carried out during the 3-month healing period. Patients were not allowed to wear a mandibular denture until final denture placement.

Retention and support for the prosthesis was obtained using a bar with two or three clips (Fig 1). Attachments or distal extensions were added to the bar in some cases to increase implant support of the mandibular denture. After an adaptation period of 3 months, new dentures were fabricated, or the existing, adequately functioning dentures were adjusted. This procedure was performed by one prosthodontist. Prosthetic features included anatomic posterior acrylic resin teeth and bilateral balanced occlusion without anterior incisal contacts.

For the first 2 years, all patients participated in a recall program at 3-month intervals. Later they were examined at 6-month intervals. Information on oral status was available for all patients at the time of study. In the ITI group, one patient was lost to follow-up after 5 years, and in the TMI group one patient was lost to follow-up after 3 years.

The following peri-implant parameters were assessed by the dental hygienist: plaque and bleeding indexes, and mucosal recession or hyperplasia. Periotest (Siemens AG, Bensheim, Germany) measurements were carried out by the prosthodontist three times per implant after removal of the bar. Since the threads of the TMI implants (posts) did not allow assessment of probing depth, these tests were not carried out for this group of patients.

Prosthetic evaluation included a clinical examination of bars and clips, assessment of the occlusion, need for remounting and relining procedures, or denture renewal. Until a major revision was performed, such as re-establishing the vertical height, the prosthesis was considered satisfactory. For evaluating prosthetic maintenance care for each implant system, the average time required for prosthetic adjustments per year (index for prostodontic aftercare) and life table were calculated.

An orthopantomograph was obtained immediately after surgery, after 6 months, and annually thereafter. Threads of the TMI posts and fenestrations of the ITI implants allowed measurements of mandibular...
height along the implants with 0.5-mm discrimination. The radiographs were also examined for the presence of radiolucencies around the implants. The success criteria of Albrektsson et al were used to denote implant status. Cumulative success rates for both groups were calculated. To evaluate the incidence of failures in severely resorbed mandibles, comparisons of subgroups with bone heights above and below 10.0 mm were made.

**Data analysis.** Differences between group means were tested by two-tailed Student’s *t* test, or by Wilcoxon rank sum test if the variables were not normally distributed. Cumulative success rates were calculated using the Kaplan-Meier product limit method. Mantel-Cox (or log-rank) testing was used to evaluate the differences between survival functions. Multivariate analysis was performed by fitting Cox’s proportional hazards model, thus permitting calculating risks and 95% confidence intervals (CI). In the multivariate analysis, risk of failure of both implants was adjusted for differences in mandibular bone height. Statistical significance was defined as *P* < .05.

**Results**

From 1983 to 1988, 36 patients were provided with ITI type F implants. Twenty-seven of these patients each received four implants, and in nine patients only three implants could be placed, resulting in a total of 135 implants. Thirty-seven patients received TMI implants during the period 1986 to 1990. In this group, two patients each received three posts, and 35 patients each received four posts, resulting in a total of 146 posts. All patients had maxillary complete dentures. Descriptive characteristics are listed in Table 1.

The follow-up period for the ITI group was 45 to 109 months with a mean of 70 months. For the TMI group, the follow-up period was from 28 to 79 months with a mean of 44 months. The bone height for both groups ranged between 7.5 and 16.0 mm. The mean bone height for the ITI type F group was 11.9 ± 2.2 mm and for the TMI group 10.9 ± 2.0 mm (*P* = .051). In approximately two thirds of the patients of both groups, a preimplant local vestibuloplasty was performed. A multiple bar provided support for the prosthesis in 36 patients with ITI type F implants and 37 patients with TMI implants. An extended bar was used in 13 patients with TMI implants, but no patients with ITI implants had extended bars. Existing adjusted prostheses were used in 10 patients with ITI and six patients with TMI implants. New prostheses were fabricated for 26 patients with ITI and 31 with TMI implants.

The peri-implant indexes for both groups are presented in Table 2. Differences in plaque, bleeding, and hyperplasia scores were not statistically significant. Significantly more recession was noted in the ITI type F group (*P* < .001). A gingivoplasty was performed in 10 patients for both systems because of muscle pull or severe gingival hyperplasia. Periotest values also differed significantly (*P* < .001): the ITI type F group varied between -6 and +5; and the TMI group varied between -5 and +39. One TMI implant could not be scored because of its high mobility. All Periotest scores were determined after removal of the bar.

After removal, 19 bars in the TMI group could not be replaced without creating tension on either implants, superstructure, or both. Five posts appeared to be extremely mobile and showed progressive bone loss. None of these implants could be associated with improper loading of the overdenture. Four posts showed increased mobility caused by improper loading; direct contacts were found between implants and the denture base. This mobility disappeared after

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<th>Table 1 Patient Population Characteristics</th>
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<td>Female</td>
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<td>Male</td>
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<td>Total</td>
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<td>Age (y)</td>
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<td>Edentulousness, maxilla (y)</td>
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<td>Edentulousness, mandible (y)</td>
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<td>Last mandibular denture (y)</td>
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<tr>
<td>Previous preprosthetic surgery</td>
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<tr>
<td>Ridge augmentation</td>
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<td>Vestibuloplasty</td>
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<th>Table 2 Peri-implant Parameters</th>
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<tr>
<td>Plaque index</td>
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<td>Bleeding index</td>
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<td>Hyperplasia (mm)</td>
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<td>Recession (mm)</td>
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<td>Periotest</td>
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NS = not significant.
elimination of the cause. All bars in the ITI type F group showed proper fit, and no mobility was found in this group.

The frequency of prosthetic adjustments and the index for prosthetic aftercare are presented in Table 3. Extensive tooth wear, loss of retentive clips, and retention problems involving the maxillary denture were the main complications. None of the dentures fractured during the follow-up period. Prosthetic aftercare in the TMI group required more time. Although not significant ($P = .416$), data related to prosthetic success strongly suggest differences between the two groups. Relative risk of failure of the dentures in the ITI type F group compared with those of the TMI group was calculated to be 0.78 (95% CI 0.42 to 1.42). Major revisions for the TMI group were generally carried out 1 year earlier than for the ITI group. After 5 years, the cumulative success rate for dentures was 37.3% for the ITI type F group and 27.6% for the TMI group.

At the time of placement, marginal bone around the ITI implants was located 3 mm apically to the implant-superstructure connection. During the first year, an initial bone loss of 1.5 mm was observed, with angular defects showing frequently. For the subsequent years, the average annual bone loss was 0.2 mm. Location of marginal bone around the TMI implants at the time of placement was not consistent. During the first year, a minimal (0.1 mm) loss of marginal bone occurred. Thereafter, the average annual bone loss was 0.2 mm. The typical angular defects seen in the ITI group were not observed in this group. No bone growth was detected in any of the patients of either implant system.

The ITI type F group demonstrated 33 (25.2%) failures in 12 (34.3%) patients. Before functional loading of the 135 placed implants, four implants in three patients were removed because of nonintegration. These early failures were caused by infection or probable overheating during surgery. After denture placement, 17 more implants in seven patients were removed; seven of the lost implants (three patients) were not replaced. All late failures (> 4 months) were associated with peri-implantitis, where progressive bone resorption had reached the inner part of the cylinder. The cumulative success rate for the ITI type F group was 87.0% at 5 years and 64.4% at 7 years (Fig 2).

The TMI group had 36 (25.2%) failures in 13 (36.1%) patients. Three patients had disturbed mental wound healing. One patient lost all four posts before loading. These early failures were the result of infection. After loading, 23 more posts in eight patients were removed; six of these patients were operated on again under general anesthesia and received new implants. The other two patients refused another operation. Causes of failed posts were peri-implantitis (seven); hyperesthesia or hyposthesia (eight); fracture (seven); and pain, mobility, and/or radiolucency (10). Fractures occurred in the nonextended-bar group (three) as well as in the extended bar group (four). Tightening of loosened cortical screws and implants was needed in four patients. The cumulative success rate for the TMI group was 71.2% at 5 years. A comparison between the survival rates of the two groups (see Fig 2) demonstrates that patients with ITI type F implants had a decreased risk of failure (relative risk 0.51; 95% CI 0.30 to 0.86). After adjusting for differences in bone height, relative risk of failure of the ITI type F implant compared with that of the TMI post was 0.55 (95% CI 0.32 to 0.95). The mean bone height of mandibles with the failed TMI posts (10.2 ± 1.5 mm) was statistically different ($P = .013$) from that of the nonfailed TMI posts (11.1 ± 2.0 mm). These differences did not appear in the ITI type F group ($P = .502$). The mean bone heights for this group were 12.1 ± 2.6 mm and 11.8 ± 2.1 mm, respectively. Cumulative success rates of the subgroups less than and greater than 10 mm are demonstrated in Figs 3 and 4.

### Discussion

Both study groups were comparable in age, gender, and mandibular bone height. The follow-up period of the ITI type F group was much longer than that of the TMI group. Most patients demonstrated excellent oral hygiene. Because no longitudinal clinical assessments of the peri-implant parameters were reported, only limited conclusions can be drawn. The higher scores for the recession values of the ITI type F group may be explained by the design of the

#### Table 3 Prosthodontic Aftercare

<table>
<thead>
<tr>
<th></th>
<th>ITI type F</th>
<th>TMI</th>
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<tbody>
<tr>
<td>Mean follow-up (months)</td>
<td>67</td>
<td>41</td>
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<tr>
<td>Clip correction</td>
<td>32</td>
<td>31</td>
</tr>
<tr>
<td>Bar correction</td>
<td>12</td>
<td>20</td>
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<tr>
<td>Renewal posterior teeth</td>
<td>26</td>
<td>18</td>
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<tr>
<td>Relining and remounting</td>
<td>37</td>
<td>27</td>
</tr>
<tr>
<td>mandibular denture</td>
<td>28</td>
<td>32</td>
</tr>
<tr>
<td>Relining maxillary denture</td>
<td>8</td>
<td>1</td>
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<tr>
<td>New maxillary denture</td>
<td>7</td>
<td>2</td>
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<td>New mandibular denture</td>
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<tr>
<td>Index (hr/y)</td>
<td>0.82</td>
<td>1.17</td>
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<tr>
<td>Ratio</td>
<td>2</td>
<td>3</td>
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Fig 2  Cumulative success rates for both implant systems ($P < .05$)

Fig 3  Cumulative success rates for the two subgroups of the ITI type F group with bone heights below or above 10 mm ($P = .26$)

Fig 4  Cumulative success rates for the two subgroups of the TMI group with bone heights below or above 10 mm ($P < .005$)
implant—the smaller transgingival part compared to the body of the implant and the resultant discrepancy with the drill hole may account for epithelial downgrowth with infrabony defects. The high location of the plasma-sprayed surfaces and fenestrations may also contribute to these relatively high scores. Such observations could not be made for the TMI system because of its design and different method of placement.

Periotest scores for the TMI were considerably higher than those for the ITI group. These values are comparable to those of natural teeth.27 Visible mobility of the implants corresponded with Periotest values greater than +20. Clinically and radiographically healthy TMI implants corresponded with Periotest values between -5 and +20. The results for the ITI type F group were consistent with those published for permucosal implants in the mandible.22,23 Healthy ITI implants corresponded with a Periotest range of -6 to -2. Failed ITI implants had a Periotest range of -2 to +5 (Fig. 5). The Periotest values suggest a relative higher mobility of the TMI implants as compared with the ITI type F. Although this comparison should be made with caution (since materials of both systems differ in modulus of elasticity and the compared implants are essentially different in design), results of the Periotest scores and mobility complications could question the quality of osseointegration of the TMI implants.

Maintenance for the multiple bar-supported overdentures was more time consuming than expected. The TMI group required more attention, and adjustments were needed earlier when compared with the ITI type F group. The acrylic resin teeth and bar clips were very sensitive to wear, causing rapid changes in occlusion and undesired incisal tooth contacts. The rigid bar construction seems to allow the patient to exert more bite and chewing force, especially in the anterior region. The box frame design of the TMI system perhaps enhances such function, as might be interpreted from the increased need for refining maxillary dentures.28 The high frequency of mandibular denture relines can be explained by the need for a refining procedure for clip corrections and the replacement of posterior teeth.

The need for maintenance of the single bar-supported prostheses was infrequently mentioned in the studies of Naert et al.7,20 Merieske-Stern20 reported the multiple-bar design to be slightly advantageous to a single-bar design for aspects such as retention, stability, and occlusal equilibration of the dentures. Observations in the present study do not support those of Merieske-Stern. This lack of agreement between studies indicates the need for investigations of prosthodontic aftercare of completely and partially implant-supported restorations.

Orthopantomographs cannot be standardized for measuring bone heights over certain periods of time. However, with the threads or fenestrations of the implants as reference points, estimates can be reliable to a 0.5-mm level. Results showed a marked loss of bone for the ITI type F group for the first year, compared with a minimal loss of bone for the TMI group over the same period. This difference may be the result of reduced surgical trauma to the periosteum in the TMI group. The presence of a smaller neck compared to the body of the ITI type F implant may contribute to a relatively large amount of early resorption for this type of implant and the typical angular defects. The observed annual loss of bone for both systems meets the minimal criteria as proposed by Albrektsson et al.24

Because of the differences in follow-up time between the two groups, it seems more appropriate to discuss cumulative success rates rather than overall success rates. Overall success or failure rates do not provide information related to the risk of implant failure over time, especially when the numbers of implant placements within each group varies per year.31,32 However, a comparison with most other studies is only possible on the basis of overall success rates because these studies often do not report cumulative success rates.31 In this study, neither type of implant met the criteria for success proposed by Albrektsson et al.24 Early failure rates for both systems were comparable, but after the first year, failures in the TMI group rapidly increased to a cumulative success rate of 55.6% after 2 years. From then, the cumulative success rate very slowly decreased to 71.2% after 5 years. The overall success rate was 74.8%. In the literature, high success rates for the TMI have been reported. Bosker and van Dijk,14 Bosker et al.,15 and Maxson et al.16 revealed success rates between 95.8% and 97.8% after long follow-up. However, in these reports the criteria for success...
were ill defined; fractured or removed and successfully replaced posts were regarded as complications rather than failures, and the individual posts were not inspected after bar removal. This may have caused an overestimation of implant success and to some extent explains the differences between these studies and the present study.

The cumulative success rate of the ITI type F group started to decrease more slowly than that of the TMI: 89.6% after 3 years and 87.0% after 5 years. After 6 years, the number of failures rapidly increased, showing a cumulative success rate of 64.4% after 7 years. The overall success rate was also 74.8%. For this type of implant, varying rates of success have been reported. Schroeder and Krekeler\textsuperscript{17} revealed a success rate of 92.0% after 3 years and ten Bruggen\textsuperscript{18} reported a success score of 95.6% after a 1- to 5-year follow-up. The present findings after 3 years support those of Schroeder and Krekeler.

Failures in the ITI group occurred at a later stage than those of the TMI group. This may be the result of differences in the type of failure. Most ITI failures were caused by infection or resorption of the bone reaching the inner part of the cylinder. These problems have been described by Ledermann.\textsuperscript{34} Since 1985, the ITI type F implant has been replaced by the Bonefit system (ITI dental implant system) with an altered implant design (Fig 6).

The TMI failures were generally of biomechanical origin. Fractures were observed in seven implants (4.9%) and tended to occur more frequently with the extended-bar superstructure, although the number of fractures was too small to be conclusive. Since 1988, TMI posts have been supplied with a modified neck. Loosened screws or posts are possibly related to problems with loading of the implant. One of the implants that had to be retightened later fractured (Fig 7). Only in the TMI group could a positive correlation between decreased mandibular bone height and implant failure be observed. These findings contradict those of previous studies that recommend the TMI as the implant of choice for extremely resorbed mandibles.\textsuperscript{14-16,19}

Fig 7 Radiographs of a TMI 1 year after surgery (top), showing some resorption around the distal implants. After 2.5 years, one of the fixation screws became loose (center), and all screws and implants were retightened under general anesthesia. One year later, two implants fractured (bottom).
Conclusion

From this retrospective study it can be concluded that:

1. Both the ITI type F and the TMI implant systems fail to meet Albrektsson’s criteria for a successful implant and show relatively low cumulative rates of success.
2. Implant-supported overdentures with a multipolar superstructure are in need of regular prosthodontic maintenance.
3. The ITI type F implant group demonstrated progressive loss of bone and infection.
4. The TMI system is sensitive to mechanical failure, especially in mandibles with decreased bone heights.

References

Une étude rétrospective sur le maintien de deux systèmes différents d’implants fut entreprise afin d’en évaluer la condition clinique, les complications, et l’entretien post-capital. Trente-six patients traités à l’aide de 135 implants endo-osseux ITI de type F, ainsi que 37 patients traités à l’aide d’implants transmandibulaires comportant un total de 146 pivots transmandibulaires furent évalués au cours de périodes moyenne de maintien respectives de 70 mois et 44 mois. Le choix du type d’implant fut influencé principalement par un changement de soutien financier de la compagnie Nationale d’Assurance de Santé aux Pays Bas en 1987. Les taux de succès cumulés furent calculés à l’aide de la méthode de produit limité de Kaplan-Meier. Dans cette analyse, le risque d’échec des implants fut ajusté en fonction des différences de hauteur osseuse mandibulaire. On n’observe pas de différence statistiquement significative entre les deux groupes de traitement concernant l’âge, le sexe, la période d’édentation, et la hauteur osseuse mandibulaire. Au cours de la période de maintien, les taux de plaques, de saignement et d’hyperplasie ne démontrèrent pas de différence entre les deux groupes. Le groupe ITI de type F démontra une récession plus significative, et le groupe implantaire transmandibulaire les valeurs de Périotest significativement plus élevées. Après ajustage des différences de hauteur osseuse, les patients traités à l’aide des implants ITI de type F démontrèrent un risque d’échec plus bas (risque relatif 0,55; 95% intervalle de confiance 0,32 à 0,95). Néanmoins, aucun des deux systèmes implantaires ne satisfaisait pleinement aux critères de succès d’Albrektsson.

Résumé
Evaluation Clinique des Overdentures Mandibulaires Soutenues par Systèmes de Barre: Étude sur le Maintien de Deux Systèmes d’Implants

Zusammenfassung
Klinische Untersuchung von implantat-gestützten Unterkiefer-Coverdentures in Verbindung mit Stegkonstruktionen: Eine Nachuntersuchung von zwei Implantatsystemen


Resumen
Evaluación clínica de sobredentaduras mandibulares soportadas por barras múltiples: Estudio de seguimiento de dos sistemas de implantes

Se efectuó un estudio de seguimiento retrospectivo para evaluar la condición clínica, complicaciones y el cuidado prostodóntico post-operatorio de dos sistemas de implantes diferentes durante un periodo largo. Se estudiaron 36 pacientes quienes fueron tratados con un total de 135 implantes endódosos ITI tipo F, y 37 pacientes tratados con implantes transmandibulares y un total de 146 postes transmandibulares. Los pacientes fueron seguidos durante 70 y 44 meses respectivamente. La decisión sobre el tipo de implante fue influenciada principalmente por un cambio en el soporte financiero de la compañía Nacional de Seguros de la Salud de Holanda en 1987. Los valores del éxito cumulativo fueron calculados utilizando el método del producto límite de Kaplan-Meier. En el análisis, el riesgo de fracaso de los implantes fue ajustado de acuerdo a las diferencias en la altura ósea mandibular. No hubo diferencias estadísticamente significativas entre los dos grupos de tratamiento en cuanto a la edad, género, periodo durante el cual estuvieron desdentados, y la altura ósea mandibular. Durante el periodo de seguimiento, no se determinaron diferencias significativas entre los dos grupos, en relación a la placa, sangrado o hiperplasia. El grupo con los implantes ITI tipo F presentó más retracciones lo cual fue significativo, y en el grupo con los implantes transmandibulares los valores del Periotest aumentaron significativamente. Luego de ajustar las diferencias en la altura ósea, los pacientes tratados con implantes ITI tipo F tuvieron un menor riesgo de fracaso (riesgo relativo 0,55, con un 95% de intervalo de confianza de 0,32 a 0,95). Sin embargo, ninguno de los sistemas cumplió con las normas de éxito de Albrektsson.

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