A Comparative Clinical Study of Three Different Endosseous Implants in Edentulous Mandibles

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The purpose of this prospective study was to investigate the clinical outcome and marginal bone resorption of three different endosseous implants placed in the anterior mandibles of 15 elderly patients. Eleven women and 4 men (ranging from 65 to 80 years, mean 71 years) had three different endosseous implants placed in the anterior mandible; one titanium plasma-sprayed cylinder implant (4-mm diameter), one titanium cylinder implant with hydroxyapatite coating (4-mm diameter), and one standard threaded titanium implant (3.75-mm diameter). Three months later, at the second-stage surgical procedure, ball abutments were connected and an overdenture was placed. At 12, 24, and 36 months, marginal bone resorption and Periotest values were recorded. None of the implants was lost in this period. An analysis of variance with repeated measurement was performed annually to test the existence of significant differences between the implants. When differences appeared, paired *t* tests were used to identify which differences were significant. Bonferroni multipliers were used to adjust for multiple testing. When marginal bone resorption was concerned, threaded titanium and hydroxyapatite-coated implants had significantly better scores than titanium plasma-sprayed cylinder implants. Periotest values for hydroxyapatite-coated implants were significantly better than test values for the other implants after 2 years. After 3 years significance was obtained between hydroxyapatite and screw-shaped implants only ($P < .05$). It was concluded that titanium plasma-sprayed cylinder implants have a less favorable prognosis than the other implants used in this study. (INT J ORAL MAXILLOFAC IMPLANTS 1998;13:500–505)

Key words: clinical follow-up, hydroxyapatite-coated implants, marginal bone resorption, overdentures, titanium plasma-spray–coated implants, titanium threaded implants

Despite adequate denture fabrication, it is not possible in many patients to achieve optimal denture retention and stability. This may be caused by poor jaw and ridge relationship, psychologic conditions, neuromuscular coordination, inadequate quality and poor location of available bone and alveolar mucosa, or inadequate vestibular depth.[1] Different treatment options are available for achieving increased retention. These include surgery to augment the alveolar ridge or to increase the vestibular depth, and placement of dental implants to provide anchorage for implant-supported prostheses or mucosa- and implant-supported overdentures. For the last two decades, preprosthetic dentistry has been increasingly dominated by implant treatment.[2–5]

Poor retention and stability is a prosthesis problem that is most frequently seen in the mandibles of elderly people. Additionally, this group may often have limited economic resources. Consequently, it is important to make implant treatment available for this group of patients. The implant-supported overdenture is an attractive treatment method primarily because of its relative simplicity, minimal invasiveness, and economic affordability. Moreover, compared to overdentures in the maxilla, this treatment has a higher rate of success.[6] Normally, two implants are sufficient to support an overdenture in the mandible. The implants can be placed on each side anterior to the mental foramina and may either be con-

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nected to each other with a bar, or function as single units with corresponding coupling units to the inner surface of the denture. Existing complete dentures can be converted for many patients, and they maintain facial support when moderate or extreme alveolar ridge resorption is present. For some patients, this approach may even be a better solution than fixed prostheses. When correctly adapted, the connecting attachment components hold the denture in position, and both implants and mucosa provide support, retention, and stability.

For this purpose, different implants with different surfaces may be used. The solid titanium screw-shaped implant introduced by Brånemark has long traditions in all treatment situations. Hollow or solid cylinder implants with hydroxyapatite or titanium plasma-spray coatings have been used for different purposes, as have screw-shaped titanium implants with different kinds of rough surface.

In this trial, three different implants were placed in each of the patients to see if success would be influenced by differences in the implant surface and configuration under similar bone conditions around the implants. Other studies with implant-supported overdentures have been carried out with a single type of implant in each patient.[2,3,5–8]

The aim of this study was to compare three different types of implants to see if surface structure or implant shape influences outcome. Another important objective was to design a simple, predictable, and affordable treatment modality for a group of patients who often are referred to the clinic.

Materials and Methods

Fifteen edentulous patients, 4 males and 11 females, mean age 71 years (range 65 to 80 years) were selected for this study. They all had conventional complete dentures and significant functional problems with their mandibular prostheses. Preoperative clinical and radiographic examination was carried out, and dental, medical, and psychosocial conditions were evaluated. None of the patients suffered from serious systemic diseases that might have increased preoperative or postoperative morbidity. Preoperatively, patients were thoroughly informed about the treatment procedure, risks, and benefits. The presurgical radiographic examination comprised panoramic and lateral cephalograms and intraoral axial radiographs of the anterior mandible for assessment of bone volume, quality, shape, and skeletal relationships. The criteria used for evaluation of implant success or failure are based on the proposals of Albrektsson et al.[9] Patients received 660 mg × 2 phenoxymethylpenicillin and a chlorhexidine mouth rinse preoperatively, and an additional 660 mg × 4 phenoxymethylpenicillin over the following 6 days. Paracetamol and codeine medication were given for postoperative pain control.

The implants used in this study were:

Group B: Threaded titanium implant, 3.75-mm diameter and 10-, 13-, and 15-mm lengths. This implant simulates the Brånemark implant, old type.

Group H: Cylinder-shaped titanium implant with hydroxyapatite plasma-spray coating, 4-mm diameter and 11-, 13-, and 15-mm lengths. This implant simulates the Integral cylinder implant.

Group T: Cylinder-shaped titanium implant with titanium plasma-spray coating, 4-mm diameter and 11-, 13-, and 15-mm lengths. This implant simulates the IMZ cylinder implant.

All implants were manufactured by 3i (Implant Innovations, Palm Beach Gardens, FL) and were sterile-packed in sealed glass ampullas. For this trial, all implants were made with a hexed-top configuration to fit the same ball abutments of the 2-, 4-, or 6-mm length. All implants functioned as single units, and no impressions or expensive technical work was needed. One implant of each type was placed anterior to the mental foramina in each patient: one in the midline and in each canine region approximately 13 mm from the midline. The distribution of implants in each individual is indicated in Table 1.

Table 1 Distribution of Implant Types in Each Patient

	Type of implant used*		
Patient no.	Right side	Midline	Left side
1	H	B	T
2	H	B	T
3	H	B	T
4	H	B	T
5	H	B	T
6	T	H	B
7	T	H	B
8	T	H	B
9	T	H	B
10	T	H	B
11	B	T	H
12	B	T	H
13	B	T	H
14	B	T	H
15	B	T	H

*H = cylinder-shaped titanium implant with hydroxyapatite plasma-spray coating; B = threaded titanium implant; T = cylinder-shaped titanium implant with titanium plasma-spray coating.

Surgery was carried out under local anesthesia (lidocaine-adrenaline, 20 mg/mL, 12.5 mg/mL). One incision was made on the alveolar crest, and a vertical midline incision was made to avoid unnecessary stress to the flap. The mental foramina were identified on both sides. If thin and sharp, the crest was reduced with bone forceps or burs before implant placement, according to standard technical advice from the manufacturer. For dense bone, the implant sites for the screw-shaped implants were predrilled. All implant sites were countersunk. Patients were not allowed to use their dentures for the first postoperative week.

When healing was satisfactory, normally after 2 weeks, the denture was adjusted by reduction of the tissue surface and relining with a soft tissue conditioner. Three months later, the abutments with ball attachment were connected. Following abutment connection, a panoramic radiograph was taken. This served as a starting point for the assessment of prospective bone resorption around the implants (ie, mesially and distally) and to reconfirm implant-abutment connection. At this stage, osseointegration was tested by means of torque forces, percussion sound, and Periotest (Siemens, Erlangen, Germany) to achieve a numerical expression of osseointegration of ankylosis.[10] This test was always conducted by the same investigator.

Approximately 1 week later, the patient's denture was placed by the prosthodontist. All patients were examined after 2 weeks to reinforce the importance of oral hygiene and to ascertain optimal function. This stage served as baseline follow-up, and initial Periotest values were recorded. Subsequently, patients were recalled for clinical examination after 3, 6, 12, 24, and 36 months. Radiographic examination and Periotest recordings were taken at the annual appointments only. Rubber o-rings were changed as necessary. For some, o-rings were replaced frequently (every 3 to 6 months), while others had the same o-rings for 1 year or more. This phenomenon seems to be related to lack of parallelism of the implants. Most of the patients had severe atrophy of the mandible, and standardized periodic identical intraoral radiographs are difficult to obtain in such cases. Consequently, to evaluate osseointegration and marginal bone loss, panoramic radiographs were used. For threaded implants, measurements were made from the top of the first thread to the marginal bone level. For cylinder implants, measurements were made from the top of the plasma-spray level to the marginal bone level on the mesial and distal side of the implant. The highest score was routinely used. Objective measurements were routinely supplemented with a patient interview about function and level of satisfaction.

Results

Marginal bone resorption around all implants ranged from 0 to 6 mm. Mean bone resorption for threaded implants after 3 years was 0.73 mm, ranging from 0 to 4 mm. Mean bone resorption for the hydroxyapatite-coated implants was 1.20 mm, ranging from 0 to 4 mm, and for the titanium plasma-sprayed cylinder implants it was 2.46 mm, ranging from 1 to 6 mm. The results after 1, 2, and 3 years are shown in Figs 1, 2, and 3. Mean bone resorption increased over time for all of the implant types.

Periotest values for all implants ranged from –6 to +7. Mean test values for all threaded implants at the 2-year and 3-year follow-ups were –1.2 and –1.9. For hydroxyapatite-coated cylinder implants, Periotest values were –2.6 and –2.3, and for titanium plasma-sprayed cylinders, values were –1.2 and –1.4 (Figs 4 and 5). Marginal bone resorption was not found around short implants (10 and 11 mm) more frequently than around long ones (15 mm). When comparing marginal bone resorption around midline implant sites to left and right implants, the following mean values were found: 1.66 mm, 1.60 mm, and 1.20 mm, respectively. During the 3-year follow-up period, there were no patient dropouts. None of the 45 implants was lost in this group of 15 patients, and all overdentures were in function. From time to time, gingival inflammation with tenderness, edema, and mild hyperplasia was seen around the abutments. This problem was resolved through oral hygiene improvement, scaling, local gingivectomy, or overdenture relief. Some of the patients had minor problems with food retention under the overdenture. In spite of these inconveniences, all patients estimated their chewing and talking capacities as considerably improved over pretreatment conditions.

Statistics. For each year, an analysis of variance (ANOVA) with repeated measures was performed to test for the possibility of significant differences between the implants. When differences appeared, paired *t* tests were used to identify which differences were significant ($P = .05$). Bonferroni multipliers were used to adjust for multiple testing. Concerning marginal bone loss, threaded titanium and hydroxyapatite-coated cylinder implants had significantly better scores than the titanium plasma-sprayed implants ($P = .05$). The differences between screw-shaped and hydroxyapatite-coated implants were not significant. Periotest values were significantly better for hydroxyapatite-coated implants than for the other implants after 2 years ($P = .05$). After 3 years, significance was obtained only between hydroxyapatite-coated cylinders and screw-shaped implants. Marginal

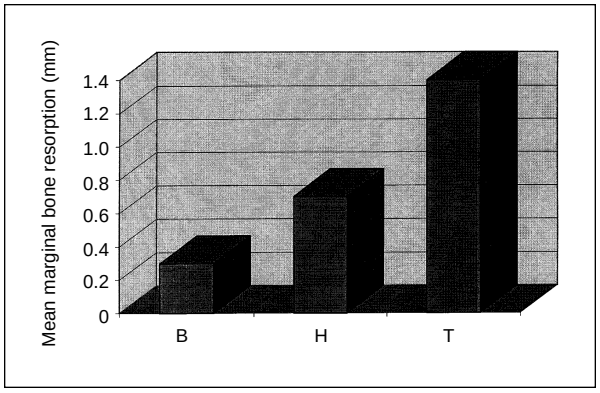

Fig 1 Mean marginal bone resorption for each implant type after 1 year (B = threaded titanium implant; H = cylinder-shaped titanium implant with hydroxyapatite plasma-spray coating; T = cylinder-shaped titanium implant with titanium plasma-spray coating).

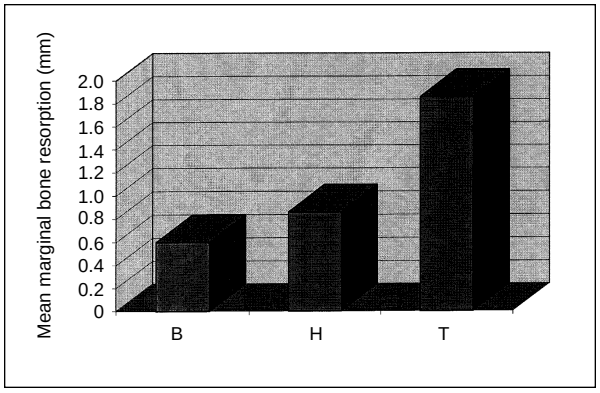

Fig 2 Mean marginal bone resorption for each implant type after 2 years.

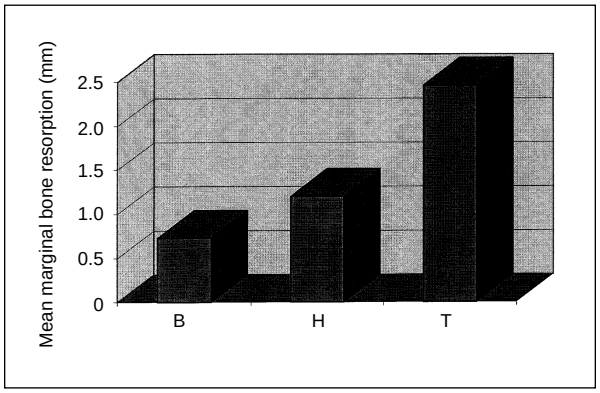

Fig 3 Mean marginal bone resorption for each implant type after 3 years.

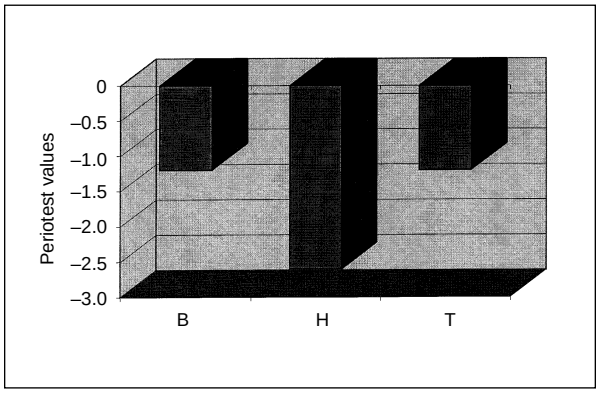

Fig 4 Mean Periotest values for each implant type after 2 years.

bone resorption related to implant sites was analyzed by means of Wilcoxon's matched pair test. The differences were not significant ($P = .05$).

Discussion

This study primarily focused on the differences in marginal bone resorption around three different endosseous implants placed in the anterior mandibles of 15 edentulous patients. Poor oral hygiene was noted in some participants. Except in one patient, this did not result in severe peri-implantitis, which is claimed to be caused by bacterial influence.[11] None of the patients was a heavy smoker, a factor that has been proven to increase implant failure.[12] Even for those implants with excessive marginal bone resorption (4 to 6 mm), Periotest values did not advance

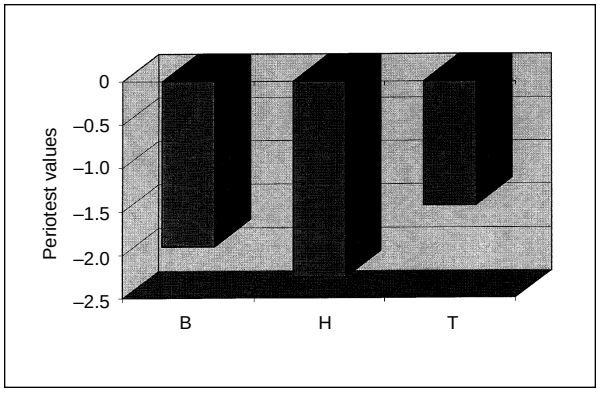

Fig 5 Mean Periotest values for each implant type after 3 years.

from the osseointegrated (ankylosis) interval 0 to stage-one mobility. Previous studies of implant-supported overdentures in the mandible have demonstrated that this treatment modality has a high rate of success.[2,4,5] The present study confirms these conclusions. When failure of an implant is related to loss, 100% of the 45 implants distributed in 15 patients survived after 3 years. However, when marginal bone resorption and increasing mobility are concerned, the choice of implant seems to be of vital importance. Spiekermann et al[13] found that titanium cylinder implants have a lower success rate compared to titanium plasma-sprayed screw-shaped implants. D'Hoedt and Schulte[14] compared the titanium plasma-sprayed cylinder implant (IMZ) to the ITI screw-shaped implants. They concluded that deepening of the peri-implant sulcus occurred more frequently around the IMZ implant, which is almost identical to the group T implant in this study. The conclusions from d'Hoedt and Schulte's study concur with the results presented here. Survival rate of 1,920 IMZ implants has been investigated by Haas et al.[15] Their results are less promising than reports from studies in which screw-shaped titanium implants have been used.

Nearly all investigations in this field have dealt with one type of implant in each patient. With three different implants in each patient, it may be possible to draw conclusions about which implant is the most or the least successful. Additionally, in this investigation bone resorption around the titanium plasma-sprayed cylinder implant was considerable, regardless of bone quality. Using three implants, one of them in the midline, there is a possibility that more stress could be transferred to this implant, leading to a higher failure rate compared to left and right implants. No special problems concerning this particular implant position were observed. However, it was noticed that mean values for bone resorption around midline implants were somewhat increased compared to side implants. In other studies in which three implants have been used in a similar way, the authors do not mention this as a problem.[16]

The increased marginal bone resorption found around the group T implant must be related to its surface or to its configuration or both. Since the group H implant has the same cylinder shape but scored significantly better in terms of marginal bone resorption, it is likely that the grooving around the group T implants, mainly related to their surface titanium plasma-spray coating, could be a factor. The lack of control of primary stability for the cylinder implants could be another influencing factor in this and other studies. Implant sites are drilled to exact diameter (4 mm) and then the implants are punched down. With screw-shaped implants, the predrilling can be omitted if the bone is loosely structured. This may secure primary stability, which is supposed to be of vital importance for the success of implants.[17]

Weinlaender et al[18] used implants with designs similar to those used in the present study in the mandibles of mongrel dogs. Histomorphometry of bone apposition around the implants showed a significantly higher percentage of bone along the hydroxyapatite-coated implants than along the titanium surface implants. This phenomenon has been confirmed by others,[19,20] who report that, at least initially, there is a stronger bone response to the hydroxyapatite-coated surface compared to the smooth titanium surface. However, at this stage it cannot be stated that this bone density lasts. If it does, it may explain why Periotest values for hydroxyapatite-coated implants are significantly better than the recordings for titanium surface implants in this study. Periotest scores in the –7 to +9 range define ankylosis or osseointegration (according to the suppliers' directions for use). Subsequently, from a clinical point of view, a score between –3 and +3 is of minor interest, because it is considered osseointegrated. Differences in Periotest scores between osseointegrated implants are influenced by the quality of the surrounding bone and by the height of its abutment.

As stated by Olivé and Aparicio,[21] Periotest is an objective and easily applied criterion for stability assessment. The test may assist the clinician in deciding if an implant should be loaded or not and may be used as a supplement to other tests when evaluating the state of an individual implant.

Conclusion

This study investigated the survival of three different endosseous implants supporting an overdenture with ball attachments in the edentulous mandibles of 15 elderly people. The results after 3 years of follow-up indicate that, compared to titanium plasma-sprayed cylinder implants, the titanium screw-shaped and the hydroxyapatite-coated cylinder implants are significantly better in terms of bone resorption. It is also concluded that an overdenture in the mandible supported by a few implants with ball attachments is a predictable, simple, and economic treatment method that can be used in most patients with expected favorable prognoses.

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