Effect of Implant Design on Preservation of Marginal Bone in the Mandible

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ABSTRACT

Background: Implant design and surface may have an influence on the marginal bone response during immediate functional loading.

Aim: The purpose of this study was to radiographically study the effect of implant design on marginal bone preservation at immediately loaded implants used for prosthetic rehabilitation of the completely edentulous mandible.

Materials and Methods: A total of 39 patients, previously treated with five implants for support of a full-arch fixed bridge in the mandible, were included in the study. Either machined Brånemark® implants (Ma) (Nobel Biocare AB, Gothenburg, Sweden) or surface modified Astra Tech® implants with (Mi) or without a microthreaded neck (Ti) (TiOblast, AstraTech AB, Mölndal, Sweden) were used. All fixtures were loaded with a provisional glass fiber or metal-reinforced screw-retained restoration within 24 hours. The provisional restorations were replaced by a 12-unit screw-retained metal-ceramic or metal-resin cantilever bridge after 3 months. Bone loss from baseline to 1 year of loading was measured by means of intraoral radiographs. Only patients with baseline and 1-year radiographs of all implants were selected for comparison. Statistical analysis was carried out on both patient and implant levels.

Results: The survival rates after 1 year in function were 98.6, 100, and 100% for the Ma, Ti, and Mi implants, respectively. The overall mean bone loss after 1 year was 1.03 mm (SD 0.87; range –0.77 to 2.5). The mean bone loss was calculated to 1.52 (SD 0.66) for the Ma group, 0.79 (SD 0.79) for the Ti group, and 0.70 (SD 1.01) for the Mi group. There was a significant difference between Ma and Ti ($p = .023$) and between Ma and Mi ($p = .046$) groups but not within Ti and Mi implants ($p = .70$). These conclusions were also valid when the statistical analysis was performed on implant level.

Conclusions: There is no impact of design and surface on implant survival in the completely edentulous mandible. Bone preservation in immediately loaded implants in the mandible is influenced by implant design and significantly better on surface-modified AstraTech implants compared with machined Brånemark implants. In the mandible, a microthread design of the implant collar does not seem to improve bone preservation.

KEY WORDS: immediate loading, implant design, implant surface, turned surface

INTRODUCTION

Turned-surface implants have been used on a large scale since the initial research initiated by the Brånemark group in Gothenburg.[1] The initial protocol for mandibular implant treatment advocated a period of subcrestal burial of the fixtures and recommended a waiting time of at least 3 months before functional loading. Today, this has been altered substantially and is not longer considered as the only procedure of first choice. One-stage surgery is feasible and yields a good long-term prognosis

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DOI 10.1111/j.1708-8208.2008.00145.x

with implant survival rates of 96 to 100% irrespective of the implant system used.[2] To improve predictability with immediate loading, enhanced implant surfaces were developed, predominantly based on increased surface roughness consequently leading to surface enlargement and increasing bone-to-implant contact area. Recent studies demonstrated higher success rate with rough surface Ti-Unite compared with turned Brånemark® implants (Nobel Biocare AB, Göteborg, Sweden) in completely[3] and partially edentulous mandibles[4,5] with comparable bone loss data.

The Astra Tech fixtures (AstraTech AB, Mölndal, Sweden) are, since 1992, made of pure titanium grade 4 and blasted with titanium dioxide particles, making the surface moderately rough. The texture of the TiOblast surface is highly uniform and has demonstrated increased bone-to-implant contact, higher regeneration of bone at defect sites, and increased stability as measured with resonance frequency compared with turned titanium surfaces.[6,7] Long-term follow-up revealed a 10-year survival rate of 96.9% and mean bone loss of 1.27 mm after 7 years.[8] In completely edentulous jaw-anchored restorations, the implants yielded 100% survival in early-loading[9] or immediate-loading[10] conditions. For 7 years, the Astra Tech implants were provided with a microthreaded implant neck as a modification of the normal design, albeit on the same TiOblast surface.[11] This design is suggested to enhance marginal bone preservation.[12]

This report discusses about the effect of the implant design on bone preservation in immediately loaded implants supporting a full-arch fixed bridge in the mandible. The study compares three implant types used by the same surgeons and with the same immediate loading protocol: (1) Turned (machined) Brånemark (Ma), (2) TiOblast (Ti), and (3) TiOblast microthread (Mi). Because both Astra Tech fixtures have the same surface configuration, the impact of fixture design on clinical survival and radiographic marginal bone level is investigated.

MATERIALS AND METHODS

Patients

A total of 39 patients (22 female and 17 male, mean age 58.4 years, range 35–77) were selected from a group of originally 43 patients, previously treated with five implants and immediate loading with a provisional full-bridge in the mandible as described elsewhere.[13,14] The patients had been referred for implant treatment, and the type of implant used depended on the demand of the restorative dentist. The idea of the present study was to form subgroups of patients treated with different implant designs and in sufficient numbers to enable statistical comparisons of marginal bone loss. Three groups could be established consisting of patients treated with either machined Brånemark implants (14 patients/70 implants) (Ma) or surface modified AstraTech implants without (15 patients/75 implants)(Ti) and with a microthreaded collar (10 patients/50 implants) (Mi). Three patients from the original group[14] treated with a fourth implant design as well as a patient with Down syndrome (who was reoperated after failure and not treated or monitored according to the protocol) were not included. The study protocol has been scrutinized and accepted by the ethics committee of the University Hospital Ghent.

Treatment Protocol

All patients were enrolled in a periodontal treatment protocol prior to implant surgery. Nonsurgical or surgical periodontal infection control, completed with selective extractions of hopeless teeth, was performed at least 2 months prior to fixture installation to minimize the risk for peri-implant infection, and oral hygiene was improved. Surgical planning was predominantly based on clinical inspection and orthopantomograms. The referring dentist provided a surgical guide plate to be used for prosthetic-driven implant placement, impression taking, and bite registration. Implants were placed after crestal incision, and full-thickness flaps were raised in order to visualize anatomic structures and available bone. The drilling protocol was adapted to the bone quality subjectively assessed by the surgeon in order to enhance initial implant stability. Implant components such as abutments and impression copings were used according to the manufacturer's guidelines, and the flap was sutured prior to impression by using the surgical guide as individual impression and occlusion registration tray. Antibiotics were not routinely administered, and patients were advised to rinse with a chlorhexidine solution during 2 weeks or used a special-care toothbrush with extra soft bristles (Special Care, Tepe, Malmö, Sweden). Paracetamol or a nonsteroidal anti-inflammatory drug was used for relieving pain. A 10-unit provisional bridge on temporary titanium cylinders and reinforced with glass fiber-

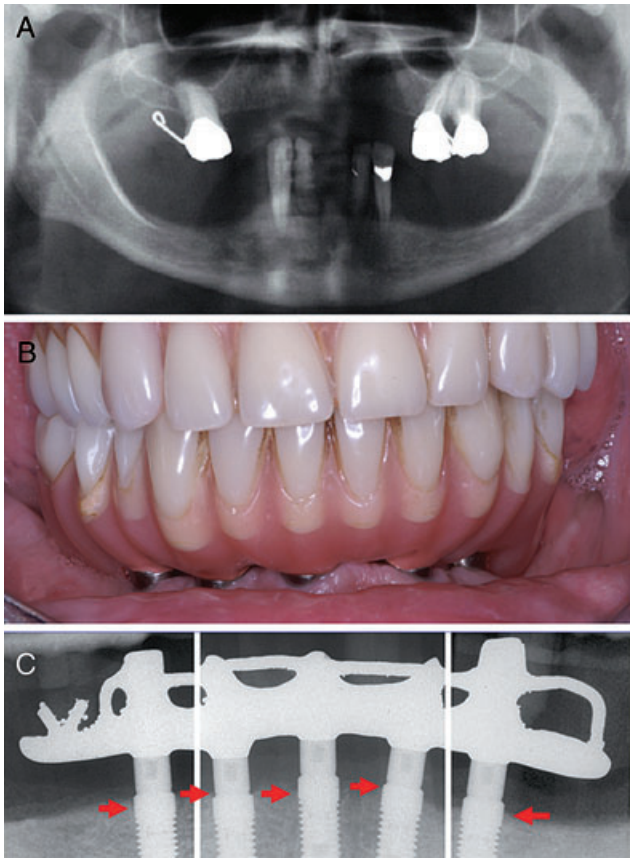

Figure 1 Clinical preoperative and postoperative pictures of one of the cases treated with TiOblast microthread implants. *A*, Preoperative orthopantomogram. *B*, Frontal view of the fixed definitive acrylic prosthesis in centric occlusion with the prosthesis in the upper jaw. *C*, Composition of apical radiographs 1 year after loading with the final bridge (red arrows represent the marginal bone level).

polymethylmethacrylate mesh (Sticktech, Sticktech Ltd. Oy, Turku, Finland) was manufactured by the dental technician and delivered within 12 hours after surgery. Minor occlusal adjustments were made to achieve spreading of the occlusal load. The provisional reconstruction was replaced by a screw-retained metal-ceramic or metal-resin reconstruction with 10 to 12 teeth. This clinical procedure was extensively described previously[10,14] (Figures 1 and 2).

Bone Loss Measurements

Intraoral digital radiographs taken at the day of provisional loading and after 1 year of loading were used. The marginal bone level was measured at mesial and distal aspects of each implant by measuring the distance from the reference point to the bone level at the nearest 0.1 mm (Visiquick, Amsterdam, The Netherlands). The reference point was the uppermost point of the vertical coronal part of the Ti and Mi implants[15] or the most coronal site of the Ma implants (Figure 3). A mean marginal bone level value was calculated for each implant based on the mesial and distal readings. The fixture mean values were then used for calculation of the patient's mean marginal bone level at the respective intervals. Bone loss was calculated as the difference between baseline and the 1-year measurements. The three groups were compared on both implant and fixture levels by using the Wilcoxon rank sum test. A statistically significant difference was considered if $p \leq .05$

RESULTS

The survival rates after 1 year were 98.6, 100, and 100% for the Ma, Ti, and MI groups, respectively. The mean 1-year marginal bone loss for the whole group of 39 subjects was 1.03 mm (SD 0.87) with a range from –0.77 to 2.50. A Kruskal–Wallis statistical test revealed that the three groups were statistically different as far as bone loss was concerned. Table 1 summarizes the mean marginal bone loss after 1 year for the three groups on patient and implant level. Wilcoxon rank sum test revealed that bone loss was more pronounced in the Ma than in both the Ti ($p = .023$) and the Mi groups ($p = .046$) (Figure 4). There was no difference between Ti and Mi implants with regard to bone loss ($p = .698$).

Only 30% of the Ma patients and implants showed less than 1.5 mm bone loss compared with 80% of the subjects treated with either Ti or Mi implants (Figures 5 and 6).

DISCUSSION

With an implant survival rate of 98.6 to 100%, this study confirms the predictable outcome with immediate loading in full-arch mandibles irrespective of the system used.[2,16–20] The survival of 98.6% with the immediately loaded machined implants corresponds to findings of Friberg and colleagues,[21] who reported a 97.5% survival rate. On the other hand, the use of rough TiUnite (Nobel Biocare AB, Gothenburg, Sweden) surface implants yielded a 100% survival after 1 year of loading.[3] A drawback of some clinical reports is the lacking of marginal bone loss data and the absence of strict success criteria. Albrektsson and Isidor[22] suggested that mean bone loss on patient level during the first year should not exceed 1.5 mm in order to consider an implant successful and 0.2 mm annually therafter. Table 1 indicates that this is

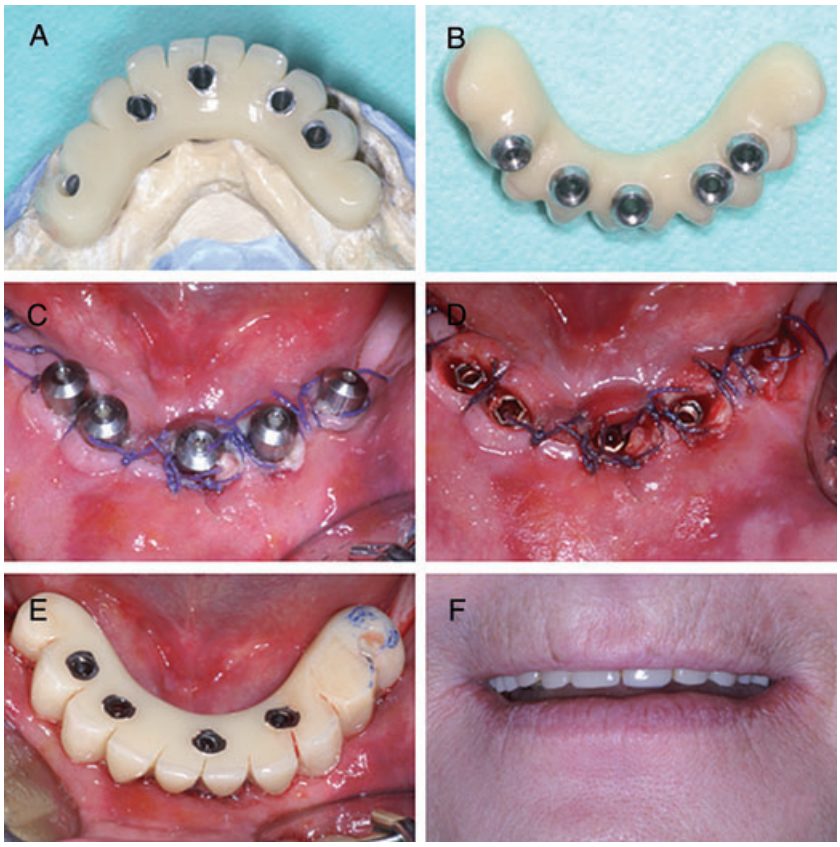

Figure 2 Clinical pictures at time of provisional prosthesis insertion of one of the cases treated with Brånemark implants. *A*, Occlusal view of the provisional metal-reinforced acrylic prosthesis delivered within 12 hours after surgery. *B*, Unattached provisional metal reinforced acrylic prosthesis. *C*, The flap is sutured around the healing abutments during the time between implant surgery and prosthesis insertion. *D*, Occlusal view on the installed implants after removing the healing abutments. *E*, Occlusal view of the temporary fixed provisional prosthesis installed on implant level delivered within 12 hours after surgery. *F*, Smile of the patient immediately after prosthesis insertion.

the case for the three groups compared in the present report. The previous reports revealed that initial marginal bone loss reflecting establishment of a peri-implant biologic attachment reached a steady state after 1 year and remained stable up to 3 years. Because additional bone loss after 1 year was not statistically significant, it was decided to compare marginal bone loss around the three implant types at the 1-year checkup.[13,14]

Figure 4, expressing a box plot of bone loss on patient level, clarifies the difference between Ma and Ti/Mi implants. Even more striking is the finding that mean patient values from Table 1 match the success

TABLE 1 Bone Loss (Mean, SD, Range in mm) After 1 Year of Loading for the Three Experimental Groups on Patient and Implant Level

Group	Mean bone loss (mm)	SD (mm)	*n*	Range (mm)	*p* Value	
Ma patients	1.52	0.66	14	0.17–0.25	<0.05	<0.05
Ti patients	0.79	0.79	15	–0.30 to 2.05	0.70	
Mi patients	0.70	1.01	10	–0.77 to 2.34		
Ma implants	1.52	0.64	70	0.17 to 2.50	<0.01	<0.01
Ti implants	0.80	0.98	75	–0.90 to 3.80	0.76	
Mi implants	0.81	1.11	50	–0.90 to 3.90		

Ma = machined Brånemark implants; Mi = surface modified Astra Tech with microthread; Ti = surface modified Astra Tech without microthread.

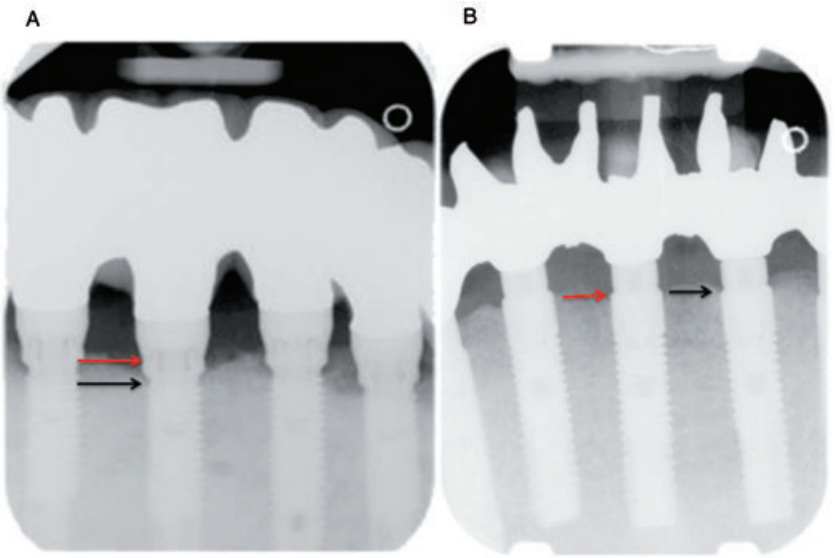

Figure 3 Radiographs representing the reference point (*red arrow*) and the marginal bone level (*black arrow*) for Brånemark implants (A) and Astra implants (B).

criteria, yet only 30% of the Ma subjects have acceptable mean bone loss values compared with 80% in both Astra Tech implants. This difference can be attributed to the implant design with the Ma implants promoting more bone loss compared to the Ti/Mi implants. This rather low success rate for the Ma implants can be attributed to the criteria[22] to distinguish success from survival. These criteria were originally described based on data obtained with two-stage surgery and delayed loading protocols and measuring marginal bone levels at a later stage of implant healing (abutment connection). One could say that, for immediate loading protocols, these criteria are stricter because initial bone resorption is added.

The effect of the microthread design but with the same TiOblast texture does not seem to enhance bone preservation in the mandible. The claim made by the

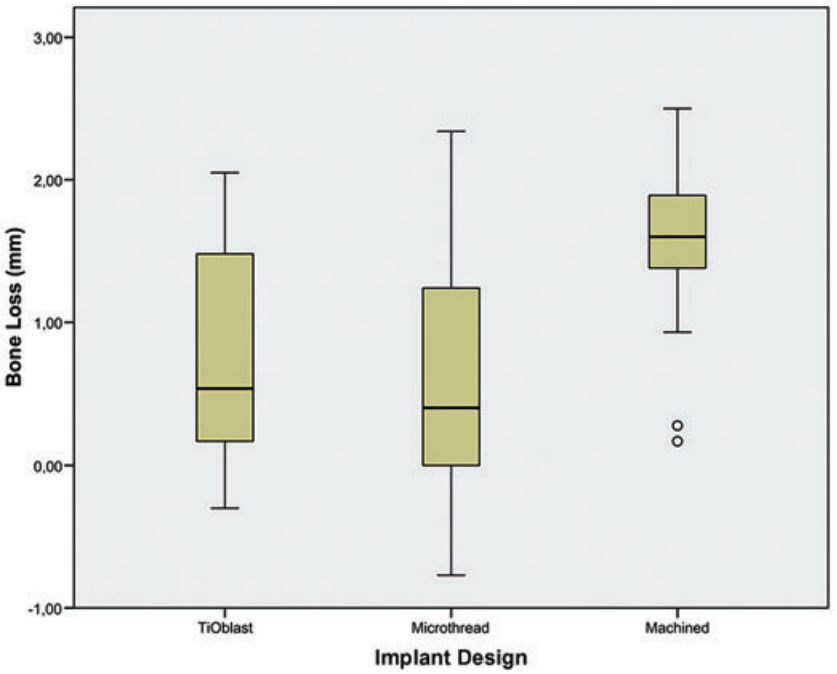

Figure 4 Boxplot representing 1 year bone loss (mm) for the TiOblast ($n = 15$), microthread ($n = 10$), and machined implants ($n = 14$). The mean patient bone loss is the unit of analysis.

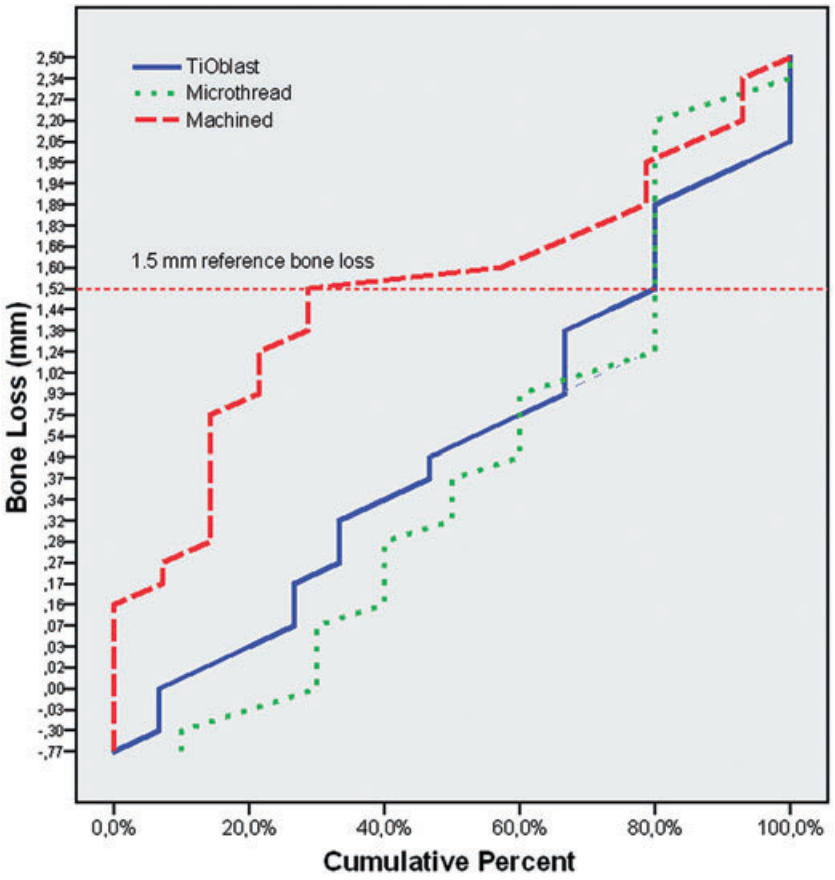

Figure 5 Cumulative percentage of patients and corresponding mean bone loss expressed in mm after 1 year of loading for TiOblast, microthread, and machined-surface implants. The 1.5 mm reference line is indicative of implant success based on the criteria of Albrektsson and Isidor.[22]

company based on previous research in vitro[11] or predominantly in the maxilla[12] cannot be sustained within the limitations of this investigation. Given the specific condition of the edentulous mandible with corticalized bone and rather thin mucosal tissues, these conclusions may not be generalized. Several studies show an inverse relation between abutment height, reflecting the thickness of mucosal tissues, and bone loss.[9,13] In cases of thin mucosal tissues, more bone loss can be expected to establish biologic width formation. In other indications such as the maxilla where we can expect thicker mucosal tissues, there might be a benefit of the microthread design in preserving bone. Collaert and De Bruyn[10] have indeed described that the microthread design preserved marginal bone in the maxilla after 1 year of loading.

A mean radiographic bone loss of 0.7 to 0.8 mm for both implant designs after 1 year of functional loading appears to be very encouraging. With the 1.5 mm bone loss taken as threshold for success, more than 80% of the subjects were treated successfully. Astrand and colleagues[15] used TiOblast fixtures in a conventional two-stage protocol. They found a mean radiographic bone loss of 1.06 mm in the edentulous mandible after 1 year of functional loading.

The clinical protocol scrutinized in this report provides the patients with a provisional full resin bridge of 10 teeth with only a minor extension distal to the last fixtures. After a 3-month provisionalization period, the final bridge was made. The benefit of replacing the short-arch bridge after the transient initial period with a final construction is adaptation to the improved function and soft tissue stabilization. Cantilever extensions of up to 2 cm in the mandible are possible, which is, for technical reasons, difficult to achieve with a provisional reconstruction.

CONCLUSION

The results show that immediate functional rehabilitation of the completely edentulous mandible is possible with turned Brånemark as well as surface-modified

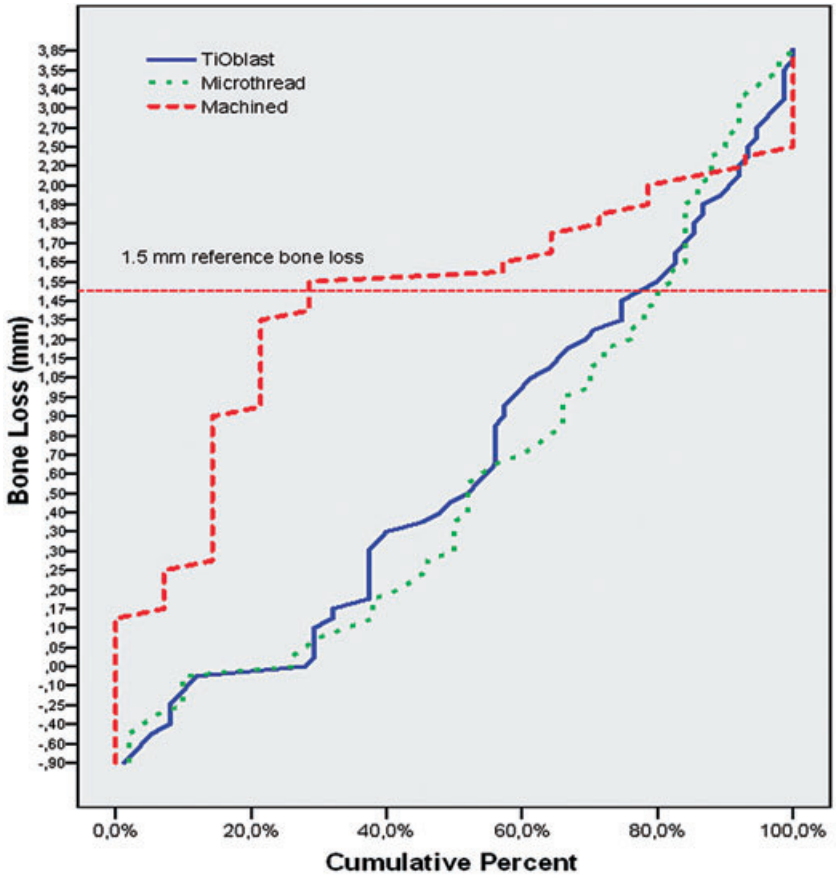

Figure 6 Cumulative percentage of individual implants and corresponding marginal bone loss expressed in mm after 1 year of loading for TiOblast, microthread, and machined implants. The 1.5 mm reference line is indicative of implant success based on the criteria of Albrektsson and Isidor.[22]

AstraTech implants. Bone loss is, however, better preserved when the Astra Tech implant design is used. Microthreads at the coronal part of the implants have no significant effect on bone preservation in the edentulous mandible.

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