A Comparison of 3 Different Endosseous Nonsubmerged Implants in Edentulous Mandibles: A Clinical Report

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The purpose of this prospective clinical study was to investigate the outcome of 3 different types of endosseous, nonsubmerged implants in the anterior part of the mandible. Fourteen older edentulous patients, 10 females and 4 males, were included. All participants received 3 different types of endosseous implants in the anterior mandible: 1 titanium plasma-sprayed cylindric implant (4 mm in diameter), 1 titanium cylindric implant with hydroxyapatite (HA) coating (4 mm in diameter), and 1 standard threaded titanium implant (3.75 mm in diameter). The 3 types of implants were originally designed to be placed in a 2-step surgical procedure. However, at this stage all implants were simultaneously provided with a temporary abutment that penetrated the mucosa. Three months later the temporary abutments were replaced by ball abutments, which were connected to an overdenture. At 12, 24, and 36 months after surgery, marginal bone resorption and Periotest values were recorded. Two patients died within the 2 first postoperative years. Five of 42 implants (11.9%) failed to osseointegrate. After 3 years, marginal bone resorption around titanium plasma-sprayed implants was significantly greater than that seen around both HA-coated and threaded titanium implants. Threaded titanium implants also had significantly better scores for marginal bone resorption than the HA-coated implants. Periotest values for HA-coated cylinders were significantly lower than test values for the other implants after 3 years ($P < .05$). The conclusion from this investigation is that nonsubmerged implants showed impaired prognoses compared to implants placed according to the 2-stage concept. Marginal bone resorption around titanium plasma-sprayed cylindric implants was clearly increased compared to the 2 other implant systems. Periotest values for HA-coated cylindric implants were superior to titanium plasma-sprayed and pure titanium implant surfaces.
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Key words: hydroxyapatite-coated implants, marginal bone resorption, nonsubmerged implants, overdentures, titanium plasma spray–coated implants, titanium threaded implants

The use of submerged dental implants to support fixed or removable prostheses for the treatment of edentulous mandibles is well documented.[1–5] During the initial phase of healing, most implant systems advocate that implants be submerged for a certain period of time before loading. The main reasons for this approach are to minimize the risk of infection, since the sockets can heal separated from the oral microbial environment. Additionally, the downgrowth of mucosal epithelium along the implant surface can be prevented and implant stability can be secured during osseointegration. This method provides for a second surgical procedure to connect the abutments before the superstructure can be attached. However, during the last few years it has been demonstrated that osseointegration can also be achieved through the use of a nonsubmerged technique.[6–9] The best documented implant system is the Bråne-

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mark system (Nobel Biocare, Göteborg, Sweden), which is based on the submerged technique. Longitudinal investigations with this implant have demonstrated high predictability.[10,11] The Astra Tech system (Mølndal, Sweden)[4] and the IMZ implant system,[12] both of which were designed for the submerged technique, and the ITI implant (Straumann, Waldenburg, Switzerland), which was designed for the nonsubmerged technique,[13] are other well-documented implant systems.

There have been few longitudinal studies of the nonsubmerged method reported with sufficient numbers of patients and long observation periods, except for the ITI implant. However, during the last decade it has been demonstrated by various investigators that implants can be properly anchored in mandibular bone and successfully used for retention of removable or fixed prostheses using a one-step surgical procedure.[14,15] Even the Brånemark implant has demonstrated good predictability in some reports when used as a nonsubmerged system.[7,16] The outcome of submerged and nonsubmerged immediately loaded Brånemark implants has been compared for a period of 10 years.[17] The survival rates were 100% and 84.7%, respectively. The relatively high failure rate of nonsubmerged implants is probably related to immediate loading. Still, the nonsubmerged concept may become the accepted method of future implant treatment, as suggested by Chiapasco et al[18] and Tarnow et al.[19]

The aim of the present 3-year prospective clinical study was to analyze the feasibility of placing 3 different endosseous implants, originally designed for a submerged procedure, using a nonsubmerged technique, and to evaluate the predictability of osseointegration and clinical success for these 3 implant types.

Materials and Methods

Fourteen edentulous patients, 10 females and 4 males (mean age 71.9 years, ranging from 65 to 80 years), were selected for this study. They all had complete dentures and significant functional problems with mandibular prostheses. Preoperative clinical and radiographic examinations were carried out, and medical and psychosocial statuses were evaluated. None of these patients suffered from systemic diseases that might have increased pre- or postoperative morbidity. They were all thoroughly informed about the treatment procedure and its risks and benefits. The preoperative radiographic examination included panoramic, lateral cephalogram, and intraoral axial radiographs of the anterior mandible for the assessment of bone volume, quality, shape, and skeletal relationships. The criteria for implant success used were based upon the proposal of Albrektsson et al.[20] Phenoxymetyl penicillin (660 mg × 2) and a mouth rinse with chlorhexidine were given preoperatively. After the placement of implants, phenoxymetyl penicillin was given daily (660 mg 4 times daily) for 6 days. Chlorhexidine mouth rinse was used until wound healing was fully accomplished and cleaning of healing abutments could be done mechanically. Paracetamol and/or codeine were given for postoperative pain control. Each patient had 3 different implants placed into the anterior mandible.

The implants used in this study were:

Group B: Threaded commercially pure titanium implant (3.75 mm in diameter) and 10, 13, and 15 mm long (3i/Implant Innovations, West Palm Beach, Florida).

Group H: Cylindric titanium implant with hydroxyapatite plasma-spray coating, 4 mm in diameter and 11, 13, and 15 mm long with an external hex (3i/Implant Innovations, West Palm Beach, Florida).

Group T: Cylindric titanium implant with titanium plasma-spray coating, 4 mm in diameter and 11,13, and 15 mm long with an external hex (3i/Implant Innovations, West Palm Beach, Florida).

All implants were packed sterile in sealed glass ampoules. For this trial they were all made with a hexed top to fit the same healing and ball abutments. One implant of each type was placed in every patient anterior to the mental foramina, 1 in the midline and 1 in each canine region. The distribution of implants in each individual is indicated in Table 1. Surgery was carried out according to the manufacturer's directions. When implants were placed in solid bone, the sites for threaded implants were tapped. For this trial, specific 2-part healing abutments were made (2, 4, and 6 mm). The healing abutments, which penetrated the mucosa, were connected to the implants immediately after placement.

When mucosal healing around the abutments was satisfactory (normally after 2 to 3 weeks), prostheses were readapted with a soft liner. The patients were not permitted to chew with their mandibular denture in the following 3-month osseointegration phase. The healing abutments were then replaced by permanent ball abutments. Prostheses were provided with matrices and connected to the abutments. This stage served as the starting point for assessment of prospective mar-

ginal bone resorption around the implants, and a panoramic radiograph was taken. At this stage, osseointegration was tested with torque forces, percussion sound, and the Periotest (Siemens, Erlangen, Germany) to achieve a numerical expression of osseointegration.[21] These tests were always done by the same investigator, as were all surgical procedures, follow-up examinations, and measurements of marginal bone resorption.

After 3, 6, 12, 24, and 36 months the patients were recalled for clinical examination. Radiographic assessments and Periotest recordings were accomplished at the annual appointments only. Most of the patients had severe mandibular atrophy. Standard periodic identical intraoral periapical radiographs can be difficult to obtain in such cases. Consequently, to evaluate osseointegration and marginal bone resorption, panoramic radiographs were used. For threaded implants, this was done on both sides, from the top of the first thread to the marginal bone level. For cylindric implants, measurements were made from the top of the plasma-spray level. The highest score was used routinely. An initial measurement was made at the time of loading.

Results

Five implants were lost within the first postoperative year (11.9%). One patient lost 2 cylindric implants, which had been placed in the left and right canine positions. Three patients lost titanium screw implants, 2 on the left side and 1 on the right side. None of these implants had properly osseointegrated after the first 3-month healing period and were, for this reason, never loaded. The marginal bone resorption around all implants ranged from 0 to 3 mm after 3 years. The mean marginal bone resorption after 3 years around the titanium threaded implants was 0.27 mm (range 0 to 2.0 mm). For titanium plasma-sprayed cylindric implants, the mean marginal resorption was 1.5 mm (range 0 to 3.0 mm), and for hydroxyapatite-coated cylindric implants, mean resorption was 0.55 mm (range 0 to 1.0 mm). After a bone healing period of 3 to 4 months, the lost implants were substituted with a submerged titanium screw implant to ensure that there would be no more inconveniences for the patients. Two patients died during the follow-up period, 1 within the first postoperative year and 1 within the third postoperative year. Both of them died from acute cardiac disease. After 3 years, 11 of 42 implants had been lost in this trial, either as the result of implant failure or patient death.

Table 1 Distribution and Location of Implant Types in Each Patient

Patient	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

H = cylindric titanium implant with hydroxyapatite plasma-spray coating; B = threaded commercially pure titanium implant; T = cylindric titanium implant with titanium plasma-spray coating.

The mean Periotest value for titanium screw-shaped implants after 3 years was +0.67 (range –2 to +4). The corresponding number for titanium plasma-sprayed cylindric implants was –0.91 (range +8 to –4), and for hydroxyapatite-coated cylinders it was –2.73 (range +3 to –5).

The differences in marginal bone resorption and Periotest values after 3 years were analyzed with a Wilcoxon matched-pair test. Significant differences in marginal bone resorption were obtained at $P < 0.05$ between both titanium plasma-sprayed cylindric implants versus hydroxyapatite-coated cylinders and titanium plasma-sprayed cylinders versus solid-screw implants (Fig 1). Periotest values for hydroxyapatite-coated cylinders were significantly lower than test values for both the solid titanium screw and the titanium plasma-sprayed cylinder. The differences between the screw implant and the titanium cylinder were not significant (Fig 2). No significant differences related to implant site were found in this trial.

Discussion

The aim of the present study was to determine the reliability of the 1-step procedure compared to the traditional and well-documented 2-step method,[1–5] for which the 3 implants used in this trial were originally designed. The nonsubmerged approach simplifies the therapeutic protocol significantly, and several investigators have demonstrated that the results can be comparable to those obtained when a 2-step surgical procedure is used,[7,16,19]

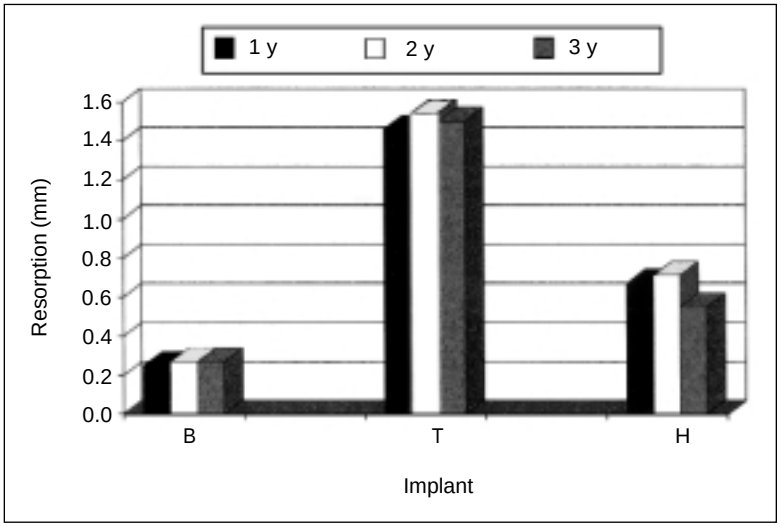

Fig 1 Mean marginal bone resorption after 1 to 3 years. B = threaded commercially pure titanium implant; T = cylindric titanium implant with titanium plasma-spray coating; H = cylindric titanium implant with hydroxyapatite plasma-spray coating.

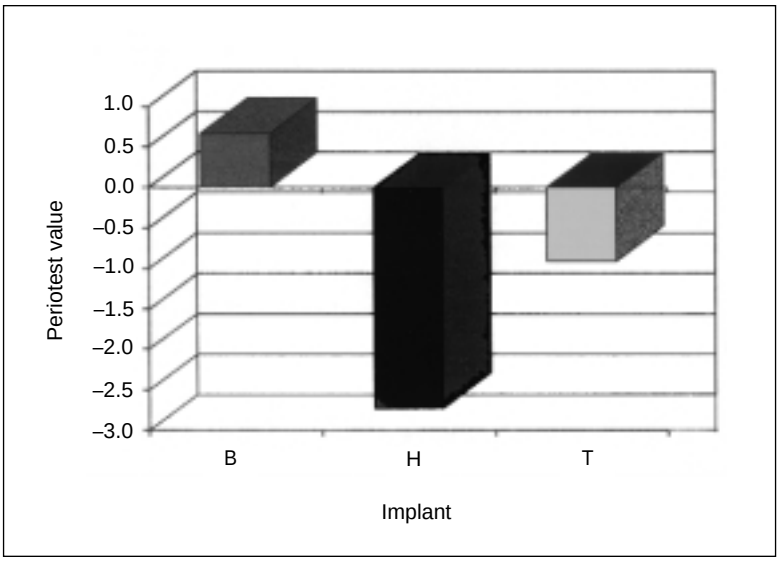

Fig 2 Mean Periotest values after 3 years. B = threaded commercially pure titanium implant; H = cylindric titanium implant with hydroxyapatite plasma-spray coating; T = cylindric titanium implant with titanium plasma-spray coating.

even for implants designed for 2-step surgery. In this trial, 5 of 42 (11.9%) implants were lost before loading, a result that is not very promising in comparison with other studies.[7,14,16]

In cases of implant failure, local factors have been sought to explain them. The patient who lost 2 cylindric implants had a very thin mandible, consisting mostly of dense cortical bone. Implants 10 and 11 mm long were placed. Furthermore, he also had powerful mental muscle activity, and the soft tissue conditions around the healing abutments (6 mm) were not ideal. Additionally, there were hygiene problems and the patient smoked. A possible explanation for why he did not lose the screw-shaped implant as well could be the threaded design, which provides better initial stability[3] compared to cylindric implants, for which sites are drilled to the same width as the implant diameter. In spite of this consideration, 3 threaded implants in 3 different patients were lost. Two of those patients were heavy smokers. Smoking has been suggested by some investigators to contribute to implant failure.[22] Additionally, soft tissue conditions in smokers may not be ideal for the nonsubmerged method. Both the healing process and overdenture function are best facilitated when

loose soft tissue is not present adjacent to abutments. No specific cause for implant failure could be identified for the third patient.

Even though the number of implants in this trial was small, the authors conclude that factors such as those mentioned above should be taken into account when a single-stage surgical technique is chosen. Marginal bone loss around surviving implants showed significant differences, with the worst results with the cylindric titanium plasma-sprayed implant. This agrees with a previous study, in which the same implants were used in a 2-stage technique.[23] The titanium plasma-sprayed surface on a cylindric implant seems to contribute to increased resorption when compared to pure titanium and hydroxyapatite-coated implants. This phenomenon may be related either to the surface or the configuration or a combination of these factors.

Periotest values were comparable to what was found in the study cited above. Hydroxyapatite-coated surfaces seem to contribute to increased bone density around implants. Morphologic studies have suggested that there is, at least initially, a higher percentage of bone around hydroxyapatite-coated surfaces, in comparison to pure titanium, titanium plasma-spray, or sandblasted titanium surfaces.[24–26] Periotest values in the –7 to +9 interval are defined as ankylosis or osseointegration (according to the supplier's directions for use). But from a clinical point of view, if an implant has a score between –3 and +3 it is considered to be osseointegrated. Differences in Periotest scores between osseointegrated implants are influenced by the quality of the surrounding bone, by the height of the connected abutment, and by the angulation of the handpiece.[27–29] As stated by Olivè and Aparicio,[30] the Periotest is an objective and easily applied method for assessing implant stability. The test may assist the clinician in deciding whether an implant should be loaded or not, but it must be regarded as supplemental to other tests when evaluating the status of an individual implant.[31]

For implants designed for 2-stage surgery, such as those used in this study, the top of the implant is intended to be flush with bone level. If this implant is left open, the microgap between the implant and the abutment may disturb the marginal bone area during the healing period. Implants designed for 1-stage surgery have a long neck that solves this problem. In this trial, in which 2-step implants were used in a 1-step procedure, this microgap may have contributed to disruption of the osseointegration process and implant failure by transmitting microorganisms from the oral environment.[32] In the authors' experience, the 2-stage method has advantages over single-stage implants when soft tissue corrections are needed. Therefore, prior to implant surgery, it is mandatory that soft tissue conditions be thoroughly evaluated. It would seem that optimal results are easier to obtain when attached keratinized mucosa surrounds the implant.

Another important issue in choosing the nonsubmerged method is that both implantation and guided bone regeneration cannot easily be performed simultaneously without increasing the risk of infection. Temporary prostheses are difficult to adjust without interfering with healing abutments, which may lead to the delivery of uncontrolled forces on the implants. In spite of these factors, other investigators have concluded that both methods have success rates that are comparable.[7,14–16] The method used for the measurement of marginal bone resorption in this trial may be questioned. However, it has been demonstrated by Sewerin et al[33] that the use of strict orthogonial projection angles does not necessarily improve diagnostic accuracy.

Conclusion

This study investigated the survival of 3 different endosseous nonsubmerged implants supporting an overdenture with ball attachments in the edentulous mandibles of 14 elderly patients. The results after 3 years suggest that the 1-stage surgical technique might be successful if certain conditions are met. There should be a sufficient amount of quality bone and good soft tissue conditions. Furthermore, it is important that healing abutments be protected from uncontrolled muscle forces or misfitted temporary prostheses. Individuals who smoke should be informed about the risk it adds to the procedure. An overall treatment result with 11.9% failure is not acceptable in the anterior mandible. It is recommended that when the nonsubmerged method is chosen, implants made for this concept should be used. However, further investigation of this clinical treatment is needed with larger patient populations and strict control of variables.

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