

# The influence of healing type on marginal bone levels of implants supporting mandibular overdentures: A randomized clinical study

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## ABSTRACT

**Aim:** The aim of this study was to document the influence of healing type on the marginal bone loss around dental implants placed in the anterior mandible.

**Materials and Methods:** A total of 48 edentulous patients rehabilitated with 96 Astra Tech dental implants left to either submerged or nonsubmerged healing were included in the study group. The patients were examined in consecutive routine recall sessions six, 12, and 24 months after loading. The actual bone level measurements were performed by two independent examiners on panoramic X-rays, and the average of both examiners' calculations was used as the marginal bone level value.

**Results:** The marginal bone loss (MBL) of the implants at 6 months was found to be significantly higher in the submerged healing group ( $P < 0.05$ ). No statistically significant relation was found between the MBL of implants left to submerged healing and that of implants left to non-submerged healing in the other follow-up periods.

**Conclusion:** In situations where the dental implant has good primary stability, non-submerged healing can be recommended to avoid a second surgery for healing abutment connection.

**Keywords:** Dental implants, mandible, over denture, oral surgery

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In clinical practice, implants can be left to heal through primary wound closure and submerged healing or by adapting the surgical flaps to a healing abutment and allowing the wound to heal with the abutment exposed to the oral cavity in a non-submerged implant healing protocol.<sup>[1,2]</sup> In the submerged healing modality, also called the Brånemark concept, a second surgical procedure is required to expose the implant for abutment connection and subsequent loading. The main thought behind submerged healing is that closure of the gingival wound minimizes the risk of infection and prevents apical down-growth of epithelium.<sup>[3]</sup> However, recent studies have shown that

osseointegration can be achieved using single-stage surgery where the implants are left to non-submerged healing.<sup>[4,5]</sup>

There are several advantages to non-submerged healing. It reduces the number of surgeries and surgical healing time, which is much more convenient for the patient.<sup>[6]</sup> It incurs a cost-benefit advantage, as well as a time benefit, since the prosthetic phase can start earlier, because there is no wound healing period involved with a second surgical procedure. It also allows the implants to be accessible for clinical monitoring during the osseointegration period.<sup>[7]</sup> Furthermore, several studies have reported that, compared with submerged healed implants, implants left to non-submerged healing showed less marginal bone loss (MBL) and the soft tissue in the vicinity was better maintained.<sup>[8-10]</sup>

It is still a matter of debate, however, whether non-submerged or submerged healing is better for the prognosis of dental implants.

Long-term clinical evaluation of dental implants and their superstructure is crucial to gathering more information about the causes of their success and failure. One of the most important success criteria is the marginal bone levels around implants.<sup>[11]</sup> The impact of submerged or non-submerged

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healing on MBL is therefore of great importance to clinicians in planning the treatment of cases with dental implants. A pathological decrease in bone level can lead to loss of bone anchorage of the implant. During the first year, MBL of 1 to 1.5 mm, and 0.2 mm annually is considered acceptable in following years.<sup>[12]</sup>

The aim of this randomized clinical study was to evaluate the relation between the submerged and non-submerged healing of mandibular interforaminal implants with a single overdenture attachment and MBL in a group of elderly edentulous patients during a period of 24 months and to draw conclusions.

## MATERIALS AND METHODS

### Patient selection

The participants in this study were edentulous implant patients at Istanbul University's Department of Prosthodontics who received two implant retained mandibular overdenture treatment during a period of 1 year. Patient inclusion criteria were the absence of any systemic disease likely to compromise implant surgery,<sup>[13]</sup> the ability to tolerate conventional surgical and restorative procedures, the ability to read and sign an informed consent document, and an agreement to attend follow-up examinations as outlined by the investigators. A total of 48 edentulous patients (30 females and 18 males) between the ages of 62 and 79 years (mean 68.34 years) fulfilled the criteria and were included in the study. The study was approved by the hospital institutional review board and all patients gave their informed consent to participate.

### Surgical procedures

All subjects received two endosseous dental implants (Osseospeed, Astra Tech; Astra Tech AB, Mölndal, Sweden) in the interforaminal region of their mandible; one in the place of tooth #22 and one in the place of tooth #27 inserted by an experienced oral surgeon who performed the implant surgery according to the manufacturer's guidelines. The implants had moderately roughened surfaces by means of TiO<sub>2</sub> grit blasting and chemically modified by incorporation of fluoride ions.<sup>[14,15]</sup> Following local anesthesia by block of the inferior alveolar and mental nerve, a mucoperiosteal flap was raised in order to have an open view to the residual crest. After evaluation of the crestal width, drilling was performed for preparation of the implant bed. The implants were placed with special attention on achieved primary stability and the subjects were randomly assigned into two groups using a lottery method. In 24 subjects, the implants were supplied with healing abutments (Zebra Healing Abutment; Astra Tech AB) and left to non-submerged healing. In the other 24 subjects, the implants were supplied with cover screws (cover screw; Astra Tech) and left to submerged healing. The wound was sutured for primary closure.

### Prosthetic procedures

New conventional maxillary and mandibular dentures were fabricated for all of the patients, using a standard prosthetic method that included balanced articulation with anatomically shaped acrylic resin teeth (Enigma; Davis Schottlander and Davis, Tonawanda, NY), maximal extension of the denture base using functional impression methods, and delivery 4 weeks after surgery. For the non-submerged group, care was taken to avoid any contact of the overdentures with the healing abutments. After 2 months of function, the prosthetic treatment started following abutment connection surgery in the submerged group and unscrewing the healing abutments and replacing them with ball abutments (Astra Tech; Astra Tech AB) in the non-submerged group. Ball abutments (Astra Tech; Astra Tech AB) and ball attachments (Astra Tech; Astra Tech AB) were used to connect the implants to the dentures by using a previously described direct processing technique.<sup>[16]</sup>

### Clinical examination

Recalls were routinely performed 6, 12, and 24 months after loading. At each recall session a clinical examination was performed. The examination evaluated prosthetic parameters such as occlusion, tissue adaptation, the condition of the retentive mechanism, as well as the condition of the denture-bearing tissues. All necessary measures were taken in case of complaints or complications.

### Radiographic evaluation

Panoramic radiographs (Planmeca Proline XC; Planmeca, Helsinki, Finland) were taken immediately after loading and at every recall session. The mesial and distal marginal bone levels of all implants were determined at baseline and recall evaluations. Measurements were obtained from images of successive radiographs, which had been scanned and digitized (Epson 1680 Pro; Seiko Epson Cooperation, Nagano, Japan) earlier, and analyzed at x20 magnification using the software program CorelDraw 11.0 (Corel Corporation and Coral Ltd., Ottawa, Canada), as described in a recent study.<sup>[17]</sup>

The known diameter of the implant at the collar region, according to the manufacturer's dimensions of the respective implants, was used as reference point. The distance from the widest supracrestal part of the implant to the crestal bone level was measured on the magnified images. To account for variability, the implant dimension (width) was measured and compared to the documentation dimensions, and ratios were calculated to adjust for distortion. Bone levels were determined by applying a distortion coefficient. The true bone height is equal to the true implant width multiplied by the bone height measured on the radiograph, which is then divided by the implant diameter measured on the radiograph.

The actual bone level measurement was performed by two independent examiners, a prosthodontist and a specialist in oral and maxillofacial radiology, neither of whom had participated in the treatment of the selected patients or knew the placement of the implants. Each examiner reviewed the radiographs on two separate occasions, one week apart. The radiographs were not available to any of the examiners between the first and second viewings. In addition, the examiners' measurements made at the first testing were not available during the second testing. During the first review, the observers did not know they would be retested.

Intraobserver reliability was determined by comparing the measurements made by each individual observer for the first and second testing sessions. Interobserver reliability was assessed by comparing the measurements made by the two different examiners. The average of both examiners' calculations was used as the marginal bone level value. The level at which the marginal bone seemed to be attached was assessed by visual evaluation at the distal and mesial surfaces of all implants.

### Statistical analyses

Statistical analyses were utilized in this study to assess the mean marginal bone level changes at 6, 12, and 24 months, as well as to explore the potential effect of submerged versus non-submerged healing on MBL around implants. Both NCSS 2007 and PASS 2008 Statistical Software (NCSS, Kaysville, UT) were used for statistical analysis of the results. Student's t-test was used to compare the marginal bone levels of the two groups at each recall and the results were assessed at the 95% confidence interval, at a significance level of 0.05.

## RESULTS

A total of 96 implants were evaluated in 48 patients 6, 12, and 24 months after loading. The MBL on the mesial and distal sites of the implants at the 6-month recall was found to be significantly higher in the submerged healing group ( $P < 0.05$ ). In the later recall sessions at 12 and 24 months, however, there was no statistically significant difference in MBL rates between the two groups ( $P > 0.05$ ; Table 1). There was no incidence of excessive bone loss with any implant and no recorded incident of peri-implant inflammation.

### Discussion

The aim of this study was to document the impact of non-submerged healing on MBL around Astra Tech dental implants. On the basis of clinical observations, bone loss ranging between 1 and 2.6 mm occurs around the margin of successfully osseointegrated dental implants.<sup>[18]</sup> In spite of the lack of consensus, since the late 80's values generally accepted as a reasonable guideline for bone loss are less than 1.5 mm for the first year postloading and less than 0.2 mm of additional loss for each following year.<sup>[12]</sup> Since it has been proposed that bone-anchored prostheses can

**Table 1: Mesial and distal bone levels in the submerged and non-submerged groups**

MBL		Submerged mean ± SD	Nonsubmerged mean ± SD	P
Distal	6 months	0.52±0.18	0.43±0.15	<i>P</i> :024*
	12 months	0.84±0.14	0.79±0.16	<i>P</i> :.260
	24 months	0.92±0.17	0.88±0.14	<i>P</i> :.292
Mesial	6 months	0.51±0.14	0.44±0.15	<i>P</i> :.015*
	12 months	0.81±0.19	0.77±0.19	<i>P</i> :.267
	24 months	0.91±0.14	0.89±0.18	<i>P</i> :.640

\* Student t-test \*  $P < 0.05$

be sustained in the oral environment for a lifetime, it is important to know the effect of different factors on bone resorption. It is worth noting that even the proposed rate of bone loss of less than 0.2 mm/year may be too liberal for young implant patients, who could lose up to 8 mm of bone over the ensuing 40 years,<sup>[19]</sup> and therefore every millimeter plays an important role in the long-term prognosis of an implant. Implant surface roughness has been shown to balance bone apposition and facilitate remodeling at the bone-implant interface, thereby minimizing crestal bone loss.<sup>[20-23]</sup> In the present study, the bone loss rate was about half that suggested by Albrektsson, Zarb, Worthington and Eriksson,<sup>[12]</sup> possibly due to our use of rough-surfaced implants and the anterior mandible being the most favorable region in which to place implants.

Radiography plays an important role in clinical routine practice and in research projects evaluating dental implants. Radiographical measurements of the marginal alveolar bone level changes over time are important parameters. Different methods have been used to assess bone height in the implant region, from merely counting the number of threads on screw-type implants to measurements by means of a computer-based interactive image analysis system. Currently the best way to measure marginal bone levels around implants seems to be by scanning and digitizing conventional radiographs, which was also the method used in this study.<sup>[24]</sup>

The bone loss documented in this study was the reduction of the bone levels at the mesial and distal sides of the implants, ignoring the so-called saucerization of the crestal bone around the neck of the implants, since only two-dimensional imaging was used. To gain more data, especially on vestibular crestal bone changes, a three-dimensional imaging technique, such as volumetric tomography, is necessary. Nevertheless, a panoramic radiograph includes both of the jaws and the teeth and is a simple examination method.<sup>[25]</sup> Furthermore, the patient's anatomy, for example, an extremely resorbed mandible or the inclination of an implant, can make placement of an intraoral radiograph impossible. Alternatively, panoramic exposure offers ease of operation and a shorter working time.

Given that the radiographs are of a high quality, Åkesson<sup>[26]</sup> concluded that for assessing the marginal bone level around

teeth, the radiographical examination of choice should be the panoramic radiograph, in accordance with a study by Persson *et al.*<sup>[27]</sup> A recent study by Kullman *et al.* also showed that panoramic radiographs were found to be as reliable as conventional intraoral radiographs when used to assess the point of bone attachment for implant threads.<sup>[28]</sup> Pikner stated that reliability can be improved with multiple readings by one observer or, even better, several independent readings by several observers, which limits the probability of a single observer's error, who may be an outlier.<sup>[29]</sup> In light of these studies, it was decided to use panoramic radiographs in the routine recall sessions of all patients, and to also supplement them, in cases of insufficient quality, with intraoral radiographs. For reliable bone loss measurements, a specialist in oral surgery and a specialist in oral and maxillofacial radiology assessed the bone levels in the radiographs.

This study was conducted to determine the most appropriate healing type for implants placed in the anterior mandible to be connected to overdentures. Besides the advantages of non-submerged healing, there are situations in which it is favorable to insert implants in a two-stage procedure.<sup>[30]</sup> For example, when a wound has to be closed tightly to prevent bone or membrane exposure or when undesirable loading of implants with a temporary superstructure during the osseointegration period must be prevented, submerged healing is the preferred treatment choice in combination with a bone augmentation procedure and guided bone regeneration.

The primary stability achieved during implant insertion is another factor influencing the choice between submerged or non-submerged healing. A two-stage procedure can be recommended if the implant has an insufficient grip in the bone. Besides using methods developed for primary stability measurement, such as insertion torque or resonance frequency analysis, an experienced surgeon can evaluate by feel the tightness of the inserted implant in the recipient site. A two-stage procedure can also be recommended when the patient is unable to perform a sufficient level of oral hygiene or when possible infections endanger general health.

Whether non-submerged or submerged healing is better for the prognosis of dental implants is still a matter of debate. There are studies reporting comparable success rates in submerged implant healing.<sup>[10,31,32]</sup> A recent study found that peri-implant bone level changes and the number of biological complications that took place during an observation period of 5 years were small and unrelated to the surgical protocol used for implant placement.<sup>[33]</sup> In the present study, the choice between submerged and non-submerged healing was made randomly, as indicated in a recent study.<sup>[34]</sup>

The results of this study have shown that, in a loading period of 24 months, there is no statistically significant relation

between dental implants supporting single overdenture attachments in the mandibular interforaminal region having healed in a non-submerged or submerged manner and marginal bone level changes. The significantly higher MBL in the submerged group at the 6-month follow-up may be explained by the additional surgical trauma in the gingiva former connection, as indicated by Buser, Weber, and Lang, who reported that less bone resorption occurs with one-stage implants because formation of the gingiva by biological width occurs in the area above the alveolar bone.<sup>[35]</sup> Furthermore, second stage surgery at the second month that was performed in the present study may have been a disadvantage for the submerged implants. During this time, the healing process is not complete. The parallel fibred bone gets remodeled at third month and lamellar bone is deposited at the fourth month making this the best time to uncover the implants.<sup>[31,32,36,37]</sup> So, the increased MBL seen in the submerged group may be due to this reason. With time there is no difference in the MBL because of the maturation process in this group.

The implants in the present study group could all be placed with sufficient primary stability, and thus a one- or two-stage procedure did not influence the outcome substantially. It is well known that, proportionally, the region with the smallest number of situations requiring submerged healing due to low insertion torque is the anterior mandible.<sup>[38]</sup> However, in the posterior maxilla, where the bone quality is very often type 4 and the achievement of good primary stability can be problematic, the non-submerged approach may lead to higher implant loss and should be judged more critically. On the other hand, within the limitations of this study, in situations with good primary stability, non-submerged healing can be recommended to avoid second-stage surgery for healing abutment connection in dental implants in the anterior mandible.

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