

All-on-4 Immediate-Function Concept with Brånemark System® Implants for Completely Edentulous Maxillae: A 1-Year Retrospective Clinical Study

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ABSTRACT

Background: Immediate implant function has become an accepted treatment modality for fixed restorations in totally edentulous mandibles, whereas experience from immediate function in the edentulous maxilla is limited.

Purpose: The purpose of this study was to evaluate a protocol for immediate function (within 3 hours) of four implants (All-on-4, Nobel Biocare AB, Göteborg, Sweden) supporting a fixed prosthesis in the completely edentulous maxilla.

Materials and Methods: This retrospective clinical study included 32 patients with 128 immediately loaded implants (Brånemark System® TiUnite™, Nobel Biocare AB) supporting fixed complete-arch maxillary all-acrylic prostheses. A specially designed surgical guide was used to facilitate implant positioning and tilting of the posterior implants to achieve good bone anchorage and large interimplant distance for good prosthetic support. Follow-up examinations were performed at 6 and 12 months. Radiographic assessment of the marginal bone level was performed after 1 year in function.

Results: Three immediately loaded implants were lost in three patients, giving a 1-year cumulative survival rate of 97.6%. The marginal bone level was, on average, 0.9 mm (SD 1.0 mm) from the implant/abutment junction after 1 year.

Conclusion: The high cumulative implant survival rate indicates that the immediate function concept for completely edentulous maxillae may be a viable concept.

KEY WORDS: acrylic prosthesis, angulated abutments, Brånemark System®, complete arch, immediate function, immediate load, maxilla, retrospective study, surgical guide, tilted implants

In a previous study, an immediate function concept for the edentulous mandible was presented with its clinical follow-up (All-on-4, Nobel Biocare AB, Göteborg, Sweden).¹ The protocol used a surgical guide for the positioning of four implants between the mental foramina to reach a favorable biomechanical prosthetic support. Advantageous load conditions made it possible to use a provisional all-acrylic prosthesis, delivered within 2 hours after surgery.

Immediate/early implant loading is well documented for the edentulous mandible,²⁻⁸ whereas only a few publications on immediate/early loading in the edentulous maxilla are available.⁹⁻¹⁴ Owing to lower bone density in the maxilla, immediate loading in this jaw region is perceived as a greater challenge than in the mandible. Furthermore, implant anchorage in the totally edentulous maxilla is often restricted owing to bone resorption, which is especially frequent in the posterior region of the maxillary arch, where bone grafting is often indicated. The use of implant tilting in the maxilla has been demonstrated to be an alternative to bone grafting.¹⁵⁻¹⁷ By tilting the distal implant, a more posterior implant position can be reached, and improved implant anchorage can be achieved by benefiting from the cortical bone of the wall of the sinus and the nasal fossa.

The use of four implants in the maxilla is encouraged by results from in vivo implant load analyses demonstrat-

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ing that favorable load distribution for complete-arch prostheses can be achieved with four implants provided that they are placed as “cornerstones”: two posteriorly and two anteriorly and well spread.¹⁸ Biomechanical analyses indicate that the most anterior and posterior implants supporting a reconstruction take the major load share at cantilever loading, irrespective of the number of intermediate implants.¹⁹ For a given distance between the anterior and the posterior implant, the load supported by the most heavily loaded implant (the distal implant) is virtually independent of the total number of implants that support the restoration. These theoretic findings are supported by the *in vivo* measurements.¹⁸ Good clinical outcomes from studies using protocols in which four implants were placed to support a full-arch prosthesis indicate that the placement of larger numbers of implants may not be necessary for successful implant treatment of edentulous jaws.^{7,20}

The purpose of this study was to retrospectively evaluate an immediate function protocol for fixed complete-arch prostheses in the completely edentulous maxilla supported by four implants (All-on-4), of which the two distal implants were tilted along the anterior sinus wall.

MATERIAL AND METHODS

The study was performed in a private clinic, Clínica Maló, in Lisbon, Portugal. Thirty-two patients (17 males and 15 females; mean age 55.1 years) were consecutively included from February 2001 to November 2003 provided that they met the inclusion criteria and gave their written consent to participate in the study.

Inclusion Criteria

The inclusion criteria were the need for complete rehabilitation of the edentulous maxilla and the possibility of placing a minimum of four implants (at least 10 mm long) into the completely edentulous maxilla, using tilting in distal sites.

The opposing dentitions were implant-supported prostheses (15 patients), natural teeth (11 patients), or a combination of both (6 patients). The bone quality and quantity of the implant sites were mainly type 3 and type C, according to the classification proposed by Lekholm and Zarb.²¹

Implant Components

One hundred twenty-eight implants (Brånemark System[®] TiUnite™ Mk III and Mk IV, Nobel Biocare AB)

were placed and immediately loaded. The length of the implants ranged from 10 to 15 mm. Eighty-five percent were Mk IV4 × 15 mm implants (Table 1). Straight and angulated (17 and 30 degrees) Multiunit abutments (Brånemark System) were used.

Each patient received four immediately loaded implants ($n = 128$). In addition to the immediately loaded implants, the first 22 patients received rescue implants ($n = 51$) placed at the time of surgery but not loaded, for use only in case of implant failure of the immediate function implants or in the final prostheses. Abutments were connected to the rescue implants at the time of surgery but were not used until a final prosthesis was delivered (at the earliest, 12 months postsurgery). The rescue implants were not included in the study. The last 10 patients, who did not receive any rescue implants, received their final prostheses after 6 months.

Surgical Protocol

The surgical procedures were performed under local anesthesia with mepivacaine chlorhydrate with epinephrine 1:100,000 (Scandinibsa 2%[®], Inibsa Laboratory, Barcelona, Spain). All patients were sedated with diazepam (Valium[®] 10 mg, Roche, Amadora, Portugal) prior to surgery. Antibiotics (amoxicillin 875 mg + clavulanic acid 125 mg, Labesfal, Campo de Besteiros, Portugal) were given 1 hour prior to surgery and daily for 6 days thereafter. Cortisone medication (prednisone 5 mg [Meticorten[®] Schering-Plough Farma, Lda, Agualva-Cacém, Portugal]) was given daily in a regression mode (15 mg to 5 mg) from the day of surgery until 4 days postoperatively. Antiinflammatory medication (ibuprofen, 600 mg, Ratiopharm, Lda, Carnaxide, Portugal) was administered for 4 days postoperatively starting on day 4. Analgesics (clonixine [300 mg, Clonix[®], Janssen-Cilag Farmaceutica, Lda, Barcarena, Portugal]) were given on the day of surgery and postoperatively for the first 3 days if needed. Antacid medication (omepra-

TABLE 1 Number of Implants According to Type and Length

Implant	Diameter, mm	Implant Length, mm		
		10	13	15
Brånemark System	3.3	2	—	—
TiUnite Mk III ($n = 15$)	3.75	2	4	7
Brånemark System	4.0	4	—	109
TiUnite Mk IV ($n = 113$)				

zole, 20 mg, Lisboa, Portugal) was given on the day of surgery and daily for 6 days postoperatively.

The clinical procedure is illustrated in Figures 1 to 9. Teeth were extracted, when needed, at the time of surgery before implant placement. A mucoperiosteal flap was raised at the ridge crest with relieving incisions on the buccal aspect in the molar area. A small window was opened to the sinus using a round bur for identification of the exact position of the anterior sinus wall (see Figures 4 and 5).

The insertion of the implants followed standard procedures, except that underpreparation was employed to achieve an insertion torque of at least 40 Ncm before final seating of the implant. Countersinking was performed when needed to create space for the head of the tilted implants and/or to secure both buccal and lingual cortical bone contact at the implant head in thin bone crests. The implant neck was aimed to be positioned at bone level, and bicortical anchorage was established whenever possible.

The implants and abutments were placed consecutively in one position at a time, starting with the two posterior locations. Most of the posterior implants had a diameter of 4 mm. The placement of the posterior implants was assisted by a specially designed surgical guide (see Figure 4). The shaft of the guide was inserted into a 2 mm osteotomy made at the midline of the jawbone, and the titanium band of the guide was bent to follow the occlusal centerline. The guide facilitated precise positioning of the implant sites in relation to the

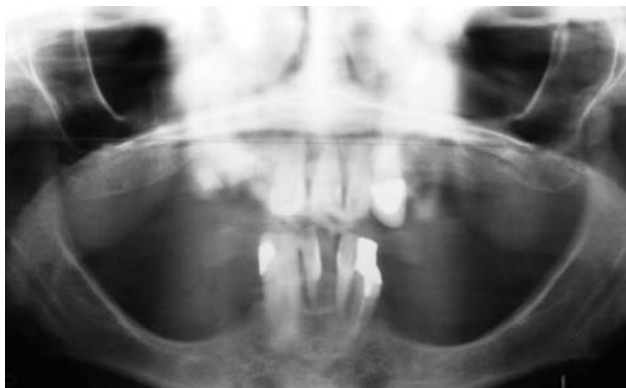


Figure 1 Preoperative panoramic radiograph from a 57-year-old female who received the treatment in both jaws on the same day. The patient had periodontally compromised teeth in both the maxilla and the mandible. After extraction of all teeth, curettage, and bone ridge adjustments, implants were placed according to the protocol. The case demonstrates a commonly encountered clinical situation, and the level of experience with the procedure for its execution was medium.

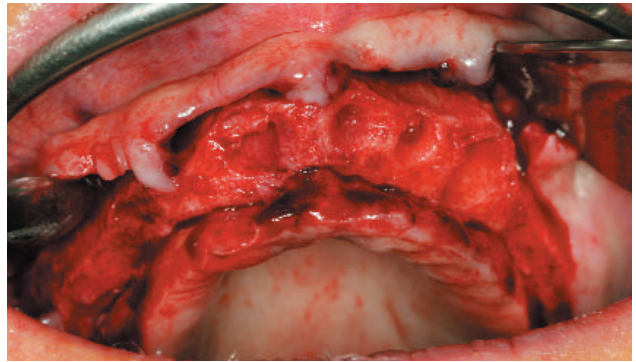


Figure 2 Clinical view with the flap raised.

opposing jaw and correct tilting of the posterior implants. Tilting the posterior implant made it possible to position the implant head in the second premolar/first molar region instead of in the canine/first premolar region in the case of a vertically placed posterior implant (see Figures 4 and 5).

The anterior implants were positioned vertically by means of a guide pin (see Figure 6). Care was taken to avoid conflict between the apices of the anterior and the tilted posterior implants. The anterior implants were most often either 4 or 3.75 mm in diameter and were typically placed in lateral or central incisor positions.

This implant arrangement resulted in a large inter-implant distance and short cantilever length (see Figures 7 and 8). After closing and suturing the flap with 3-0 nonresorbable suture, the abutments were accessed by means of a punch, and impression copings were placed.

Immediate Prosthetic Protocol

Provisional complete-arch all-acrylic prostheses were delivered on the day of surgery ($n = 32$). A premade

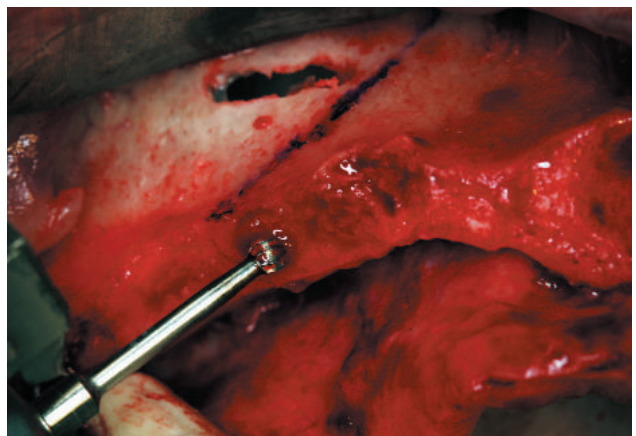


Figure 3 Clinical view showing the posterior implant location and the sinus window.

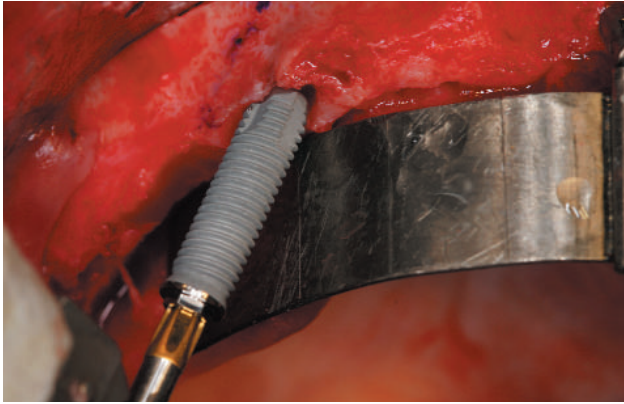


Figure 4 Clinical view showing the specially designed surgical guide at the time of posterior implant insertion.

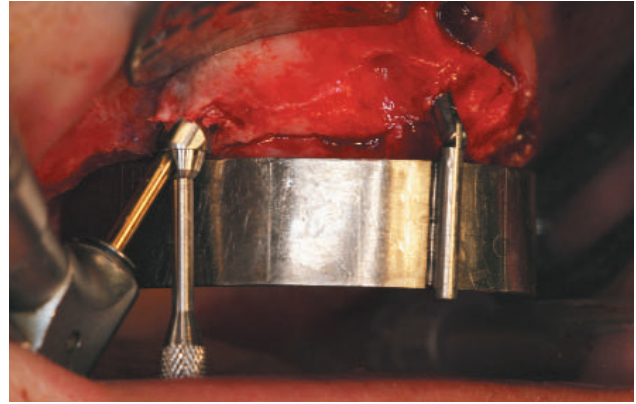


Figure 5 Clinical view of the abutment placed on a posterior implant.

impression tray was used. Small volumes of silicon were placed around the copings, followed by complete filling with soft putty. After removal of the copings, protection caps were placed to support the periimplant mucosa during the manufacturing of the prosthesis. Based on the impression, a high-density baked all-acrylic prosthesis with titanium cylinders was manufactured at the

laboratory and most often delivered to the patient within 3 hours (see Figure 9).

Final Prosthetic Protocol

Final prostheses were delivered, at the earliest, 12 months postsurgery for patients with rescue implants ($n = 22$), at which time these implants were connected for the first

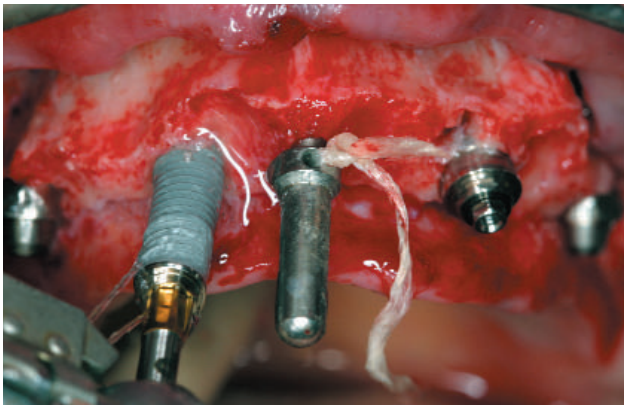


Figure 6 Clinical view showing the direction guide at anterior implant insertion.



Figure 7 Clinical view of all implants in place.

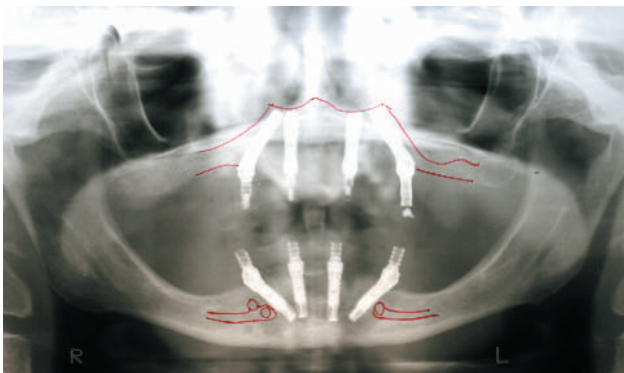


Figure 8 Postoperative panoramic radiograph.



Figure 9 Provisional prosthesis in place.

time. The patients with four implants only ($n = 10$) received their final prostheses at 6 months. If an adjustment of the angulated abutment was needed for better positioning of the screw access hole, the impression for the final prosthesis was taken at implant level. The abutment position was then decided at the laboratory and was adjusted in the patient's mouth.

Implant Survival Criteria

An implant was classified as surviving if it fulfilled its purported function and was stable when tested individually, if no pain or signs of infection were detected during clinical examination, and if no sign of periimplant pathology was seen at the radiograph.

Follow-Up and Marginal Bone Level

Follow-up examinations were performed 6 months and 1 year after implant placement. Intraoral or panoramic radiograph examinations were performed at the 1-year follow-up (no baseline at surgery was established). For the intraoral technique, a conventional radiograph holder was used, the position of which was adjusted manually to ensure orthogonal film positioning. The implant-abutment interface was taken as a reference point for the bone level measurements. An independent radiologist performed the radiographic readings.

RESULTS

Implant Survival

No patient was withdrawn from the study, and all patients (32 patients, 128 immediately loaded implants) were followed for 1 year. Three implants in three patients were lost (two Mk IV 4×15 mm implants and one Mk III 3.75×15 mm implant), giving a cumulative survival rate of 97.6% (Table 2). All failures were posterior implants.

Failures and Remedies

Two of the patients who lost one implant each were heavy bruxers. One of the implants was lost after 1 month and one implant after 9 months, although signs of failure

started at 3 months. It is believed that the load-bearing capacity of the bone was not sufficient to withstand the high loads in these cases. The third implant failure occurred in soft bone in which sufficient initial stability could not be reached. The implant was taken off load after 1 month (time of failure) and the provisional prosthesis was adjusted, but, 8 months later, the implant was still not integrated. In one patient, the prosthesis was adjusted after implant failure and survived on the three remaining implants until the final prosthesis was attached to newly inserted implants. In two other patients, the prostheses survived by putting into function one of the rescue implants.

Marginal Bone Level

Readable radiographs were obtained for 31 of the 32 patients (99 mesial and 98 distal positions). The rescue implants were not measured because they were not part of the study. At the end of the observation period, the bone level was situated, on average, 0.9 mm (SD 1.0 mm) below the implant-abutment interface (Table 3). Five implants showed bone levels exceeding 3 mm at the distal position.

Mechanical Complications

No fractures or loosening of abutment or prosthetic screws were observed during the study. The only mechanical complications recorded were fractures of prostheses in four bruxing patients, of whom two were patients who lost one implant each. The prostheses were easily mended and served well after revision.

DISCUSSION

In the present study, three patients lost one implant each, giving a cumulative survival rate of 97.6% for immediately loaded implants in the maxilla. The result compares favorably with other reported immediate/early loading protocols for the same indication.⁹⁻¹⁴ The mean bone level (0.9 mm) obtained after 1 year of functional loading was in accordance with previous experience on early function with the same type of implants.²²

TABLE 2 Life Table Analysis

Time Period	Functioning	Failed	Withdrawn	Survival Rate, %	CSR, %
Loading-6 mo	126	2	0	98.4	98.4
6 mo-1 yr	125	1	0	99.2	97.6

CSR = cumulative survival rate.

TABLE 3 Bone Level Relative Implant Platform

	Mesial, mm (n = 99)	Distal, mm (n = 98)	(M + D)/2, mm (n = 100)
Minimum	0.0	0.0	0.0
Maximum	3.7	5.0	4.0
Average	1.0	0.9	0.9
SD	1.0	1.1	1.0

High survival rates have been frequently reported in the literature for immediate function of fixed mandibular complete-arch prostheses supported by three or four implants.^{1,4,23–25} However, when immediate loading is applied in the maxilla, a larger number of implants is generally used,^{9–13} although documented experience on delayed loading has shown equivalent outcomes when comparing the use of four or six maxillary implants as support for fixed full-arch prostheses.^{17,20}

The present treatment concept uses the load-bearing capacity of the maxillary bone in a favorable way. Owing to the freedom of tilting, the implants can be anchored in dense bone structures (anterior bone with higher density) and well spread anteriorly-posteriorly, giving an effective prosthetic base.^{15,18,19} By reducing the number of implants to four, each implant can be placed without coming into conflict with adjacent implants. This treatment approach, using tilting and few implants rather than inserting several implants competing for space, has demonstrated good results in a previous study with delayed loading.¹⁷ The present treatment concept adds immediate loading to this experience. To our knowledge, no published clinical studies have investigated immediate loading of four implants as support for fixed complete-arch restorations in the maxilla.

To accomplish immediate function, an all-acrylic prosthesis was placed within a few hours after surgery. All-acrylic prostheses are frequently used as provisional restorations for immediate loading. Although this type of prosthesis has sometimes been associated with fracture problems, it seems to function well if carefully designed and manufactured and if good implant support is provided.^{26–28} In the present treatment concept, a distal position of the posterior implant is reached by tilting, reducing the maximum cantilever length to one tooth, resulting in reduced mechanical stress to the prosthesis. In vivo load measurements show that the acrylic material per se does not influence the load dis-

tribution in a reconstruction with short cantilever arms.^{29,30} The clinical results of the present study suggest that an accurately designed and supported all-acrylic prosthesis serves well as a provisional complete-arch restoration and may be successful if used for a longer term than only during the healing period.

CONCLUSIONS

Within the limits of the study, the following conclusions were drawn:

- Immediate functional loading using four implants as a support for a full-arch maxillary prosthesis demonstrated a high implant survival rate (97.6%) after 1 year of loading.
- Tilting of posterior implants was compatible with a high survival rate.
- The use of all-acrylic provisional prostheses may be a viable option for immediately loaded complete-arch restorations in the maxilla, at least when short cantilevers are used.

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