# Immediate Rehabilitation of the Completely Edentulous Jaw with Fixed Prostheses Supported by Either Upright or Tilted Implants: A Multicenter Clinical Study

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***Purpose:*** *The aims of this study were to assess the treatment outcome of immediately loaded full-arch screw-retained prostheses with distal extensions supported by both upright and tilted implants for the rehabilitation of edentulous jaws and to compare the outcomes of upright versus tilted implants.* ***Materials and Methods:*** *At 4 study centers, 342 Osseotite NT implants were consecutively placed in 65 patients (96 implants were placed in 24 mandibles and 246 implants in 41 maxillae). The 2 distal implants were tilted by 25 to 35 degrees. Provisional full-arch restorations made of a titanium framework and acrylic resin teeth were delivered within 48 hours of surgery and immediately loaded. The final prosthesis was delivered after 3 months of healing.* ***Results:*** *Three implants failed during the first year and another 2 within 18 months of loading in the maxilla. The cumulative implant survival rate for the maxilla was 97.59% for up to 40 months of follow-up. No implant failure was recorded for the mandible. The prosthetic success rate was 100%. Marginal bone loss around upright and tilted implants was similar. Patients were satisfied of their esthetics, phonetics, and function.* ***Conclusion:*** *The preliminary results of this study suggest that immediate rehabilitation of the edentulous maxilla and mandible by a hybrid prosthesis supported by 6 or 4 implants, respectively, may represent a viable treatment alternative with respect to more demanding surgical procedures. The clinical results indicate that immediately loaded tilted implants may achieve the same outcome as upright implants in both jaws.* (Clinical Trial) Int J Oral Maxillofac Implants 2007;22:639–644

**Key words:** *dental implants, edentulous jaw, immediate loading, tilted implants*

The immediate rehabilitation of a fully edentulous maxilla or mandible with a fixed prosthesis supported by osseointegrated implants represents 1 of the most remarkable achievements in clinical dentistry. The predictability of such a treatment is documented by a growing body of literature.[1–4]

From an anatomic standpoint, the rehabilitation of edentulous posterior regions with endosseous implants is often complicated by poor bone quality and by the limited quantity of bone in this region, especially in the maxilla. According to the original concept for the placement of Brånemark System implants in an atrophied completely edentulous arch, the implants should be placed in a fairly upright position.[5,6] Consequently, it is often necessary to fabricate a bilateral cantilever up to 20 mm long so as to provide the patient with acceptable chewing capacity in the molar regions. Such a restoration creates biomechanically unfavorable conditions; cantilevers longer than 15 mm have been associated with higher implant-prosthesis failure than shorter cantilevers.[7]

The clinically documented technique of tilting of posterior implants was developed for improving bone anchorage and prosthesis support and avoiding bone grafting procedures.[8–13] The use of tilted implants in the residual crestal bone may have several clinical advantages: *(1)* This technique makes it possible to place longer implants, which should increase the implant-to-bone contact area as well as the implant primary stability. *(2)* Tilting the implant creates a wider distance between anterior and posterior implants, which should result in better load distribution. *(3)* The technique reduces or eliminates the need for cantilevers in the prosthesis. *(4)* The technique can reduce or eliminate the need for bone

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augmentation procedures such as sinus lift or crestal elevation in atrophic regions.

The aims of this clinical study were to evaluate the treatment outcome with immediately loaded full-arch fixed prostheses supported by a combination of upright and tilted implants in patients with completely edentulous jaws up to 5 years and to compare the outcomes for upright and tilted implants. This preliminary report presents data on the implant survival and on peri-implant bone loss after up to 3 years of function.

## MATERIALS AND METHODS

### Inclusion and Exclusion Criteria

Patients with completely edentulous mandibles or maxillae were selected on the basis of the following inclusion criteria:

- Age of at least 18 years
- Severe atrophy of the mandible or maxilla such that bone augmentation would have been necessary for placing implants in the posterior region
- Rehabilitation with oral implants considered elective
- Physical ability to tolerate conventional surgical and restorative procedures (ASA 1 to 2)[14]
- Willingness to sign informed consent form

Patients were only included if the implants could be seated with a torque between 30 and 50 Ncm. If 1 or 2 of the upright implants could not reach 30 Ncm, immediate loading was still allowed, since those implants were splinted to adjacent implants. If 1 of the tilted implants or 3 or more of the upright ones could not be inserted with a torque of at least 30 Ncm, immediate loading was not applied, and the prosthetic phase was postponed after a healing period of at least 2 months.

Exclusion criteria were

- Presence of active infection or inflammation in the areas intended for implant placement
- Presence of systemic diseases, such as uncontrolled diabetes
- Irradiation in the head and neck regions in the previous 12 months
- Undeniable need for bone augmentation at the intended implant site
- Presence of previously placed unresorbed allograft at the implant site
- Severe bruxism or clenching habits
- Pregnancy
- Poor oral hygiene and motivation

Patients were recruited and treated at 4 clinics in Northern Italy by surgical teams with expertise in implant dentistry.

### Surgical Aspects

Prior to surgery, the patients were sedated with diazepam (Valium, 10 mg; Roche, Milan, Italy) and received prophylactic antibiotics (amoxicillin and clavulanic acid; Augmentin; Roche, Milan, Italy, 2 g 1 hour before surgery). Implant surgery was performed using local anesthesia with articaine 1:100,000 (Ubistein; 3M/Espe, Segrate, Milan, Italy).

For both the maxilla and mandible, a crestal incision was made from the first molar to the first contralateral molar. Two distal vertical incisions were performed to allow for easier flap elevation. A mucoperiosteal buccal flap was then raised.

### Mandible

In the mandible, after flap elevation, the mental foramina were identified. This anatomic landmark was assessed with a periodontal probe to detect the anterior mental loop. The anterior mental loop was used to determine the angulation of the posterior implant. Figures 1 and 2 show preoperative views of a mandibular case. The most posterior implant was placed in the crestal bone in correspondence with the mental foramina. This implant was tilted approximately 25 to 35 degrees (Fig 3a). After the placement of 2 posterior implants bilaterally, 2 implants were placed in the anterior space between the mental foramina (Fig 3b).

### Maxilla

A preoperative view of a maxillary case is shown in Fig 4. For patients with completely edentulous maxillae, the position of the anterior sinus wall was determined by looking through a small window created in the lateral sinus wall (Fig 5a). The most posterior implant was placed 3 to 4 mm from and parallel to the anterior sinus wall. This implant was tilted approximately 30 to 35 degrees, with the posterior side 1 to 2 mm anterior to the medial sinus wall (Fig 5b). Subsequently, 2 implants were placed in the anterior maxilla parallel to the midline. Then, in the available space between the implants already placed, 1 more implant was placed per side[8] (Figs 6 and 7).

All implants (Osseotite NT; Biomet/3i, West Palm Beach, FL) were positioned with a 1-stage procedure in a crestal or subcrestal neck position. Flaps were sutured around healing abutments (Figs 8a and 8b). If implant inclination exceeded 30 degrees, angulated abutments were used.

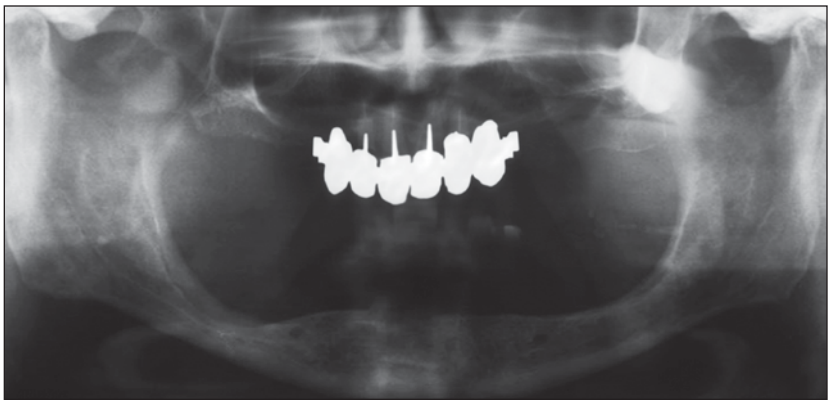
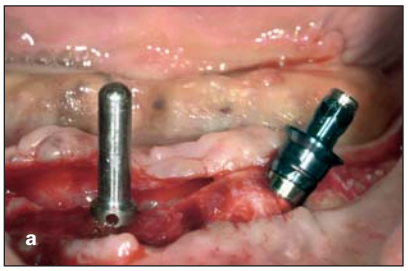


**Fig 1** Before implant placement, the maxillary anterior teeth were extracted, and the bone was allowed to heal for 2 months.

**Fig 2** Intraoral occlusal view of the mandible before surgery.

**Fig 3a** Anterior view of the guide pin and the distal implant, which was tilted approximately 25 to 30 degrees.

**Fig 3b** Anterior view of the 4 implants placed with the 2 distal implants tilted.



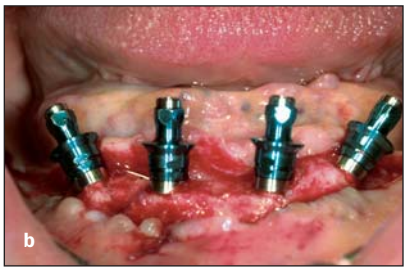




**Fig 4** Intraoral anterior view of the maxilla before surgery.

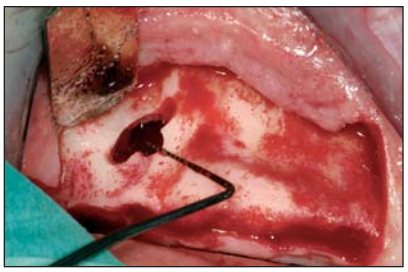


**Fig 5a** After flap elevation, the anterior sinus wall was detected through a lateral bone window.

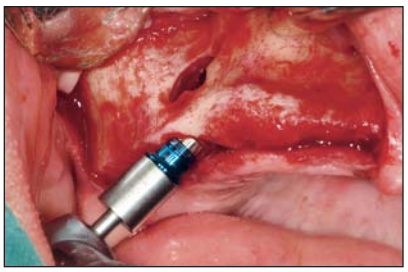
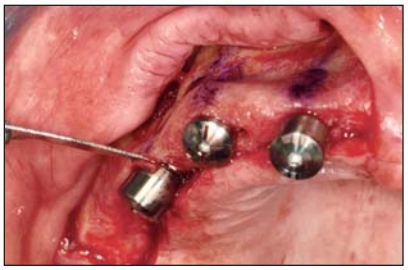


**Fig 5b** The distal implant was tilted approximately 25 to 35 degrees and was located 1 to 2 mm mesial to the anterior sinus wall.

**Fig 6** *(left)* The second implant was positioned parallel to the midline. Lines were drawn on the bone with a dermographic pencil indicating the implant lengths.

**Fig 7** *(right)* Right-side implants before suturing. Healing abutments have been placed on the mesial and distal implants.



Panoramic radiographs were obtained at the end of the surgical phase, and an impression of the implant position was made.

## Prosthodontic Treatment

Temporary prostheses were delivered within 48 hours of the end of the surgery. Complete full-arch prostheses consisted of a titanium framework with acrylic resin teeth. The abutment screws were tightened at 10 Ncm using a torque control device.

The definitive prosthesis was delivered after 3 months of healing for both the maxilla and mandible. Complete full-arch prostheses were fabricated with a titanium framework combined with new acrylic resin teeth composed of 12 elements (Figs 9a and 9b). The posterior cantilever length was extended to allow a first molar chewing surface.

The definitive prosthodontic framework was tightened with gold screws at 20 Ncm (Goldtite; Biomet/3i). Once the prosthesis was finalized, the

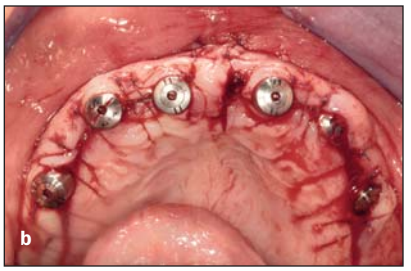


**Fig 8a** Four mandibular implants with healing abutments after suturing.

**Fig 8b** Occlusal view of the maxillary implants with healing abutments after suturing.

**Fig 9a** Definitive prosthesis 2 months after surgery.

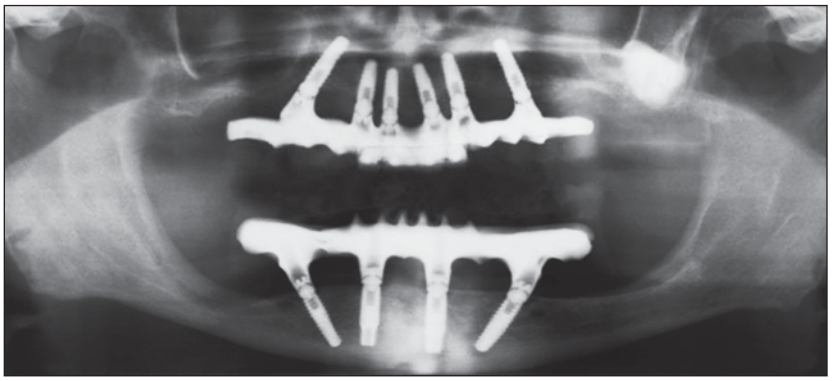


**Fig 9b** Note tilting of the implants in the mandible in relation to the mental foramen. In the maxilla, posterior implants were placed parallel to the anterior sinus wall.

patient completed a satisfaction evaluation questionnaire regarding esthetics, phonetics, ease of maintenance, and functional efficiency. The questionnaire was repeated at each annual evaluation.

### Success Criteria

Implants were considered successful if they did not exhibit or were not associated with clinically detectable mobility when tested with opposing instrument pressure, evidence of peri-implant radiolucency, recurrent or persistent peri-implant infection, or complaints of pain, neuropathy, or paresthesia. Crestal bone loss could not exceed 1.5 mm by the end of the first year of functional loading or 0.2 mm/year in subsequent years.[15]

### Follow-up

No specific diet was recommended to patients. They were scheduled for follow-up evaluation at 3, 6, and 12 months postsurgery and then annually up to 5 years. At each follow-up visit periapical films were obtained using a paralleling technique for marginal bone loss evaluation.

Crestal bone loss was evaluated with a computer-aided technique as previously described.[16] Bone loss around tilted and upright implants was compared by means of an unpaired Student *t* test. The significance level was considered $P = .05$. Cumulative implant survival over time was assessed using Kaplan-Meier analysis.

## RESULTS

### Demographics

Between May 21, 2002, and May 31, 2006, 65 patients (43 women and 22 men) were enrolled in this study. Ten of the included patients were smokers. The average age at surgery was 59.2 years (range, 28 to 83 years). Twenty-four mandibles (96 implants) and 41 maxillae (246 implants) were rehabilitated by immediately loaded full-arch fixed prostheses supported by both upright and tilted implants. All implants were seated with a torque ≥ 30 Ncm, and all patients were rehabilitated according to an immediate loading protocol as planned. One female patient who was rehabilitated in the maxilla died 4 months after surgery because of a car accident and was therefore omitted from the study.

Two upright maxillary implants and 1 tilted implant failed during the first 12 months after placement. Two more failures were recorded (1 tilted maxillary implant and 1 upright maxillary implant) during the second year of function. The maxillary cumulative implant survival rate was 97.59% up to 40 months (mean follow-up, 22.5 months) of loading. No failure was recorded in the mandible to date, resulting in a cumulative implant survival rate of 100% with up to 52 months of follow-up (mean follow-up, 29.1 months). None of the prostheses failed, providing a prosthetic success rate of 100% for both jaws. Tables 1 and 2 show Kaplan-Meier analyses for the mandible and maxilla, respectively.

**Table 1 Life Table Analysis—Mandible**

| Interval (mo) | No. of patients | No. of implants | Upright | Tilted | Implant duration | No. of failures | Interval survival rate (%) | Cumulative survival rate (%) |
|---|---|---|---|---|---|---|---|---|
| 0–6 | 24 | 96 | 48 | 48 | 4 | 0 | 100 | 100 |
| 6–12 | 23 | 92 | 46 | 46 | 4 | 0 | 100 | 100 |
| 12–18 | 22 | 88 | 44 | 44 | 4 | 0 | 100 | 100 |
| 18–24 | 21 | 84 | 42 | 42 | 4 | 0 | 100 | 100 |
| 24–36 | 20 | 80 | 40 | 40 | 68 | 0 | 100 | 100 |
| > 36 | 3 | 12 | 6 | 6 | 12 | 0 | 100 | 100 |

**Table 2 Life Table Analysis—Maxilla**

| Interval (mo) | No. of patients | No. of implants | Upright | Tilted | Implant duration | No. of failures | Interval survival rate (%) | Cumulative survival rate (%) |
|---|---|---|---|---|---|---|---|---|
| 0–6 | 41 | 246 | 164 | 82 | 30 | 2 | 99.18 | 99.18 |
| 6–12 | 36 | 214 | 143 | 71 | 36 | 1 | 99.53 | 98.71 |
| 12–18 | 30 | 177 | 118 | 59 | 18 | 2 | 98.87 | 97.59 |
| 18–24 | 27 | 157 | 105 | 52 | 30 | 0 | 100.00 | 97.59 |
| 24–36 | 22 | 127 | 85 | 42 | 115 | 0 | 100.00 | 97.59 |
| > 36 | 2 | 12 | 8 | 4 | 12 | 0 | 100.00 | 97.59 |

All patients were satisfied with the phonetics, esthetics, and psychologic and functional aspects once treatment was completed.

At the 12-month evaluation, peri-implant crestal bone loss averaged 0.95 ± 0.44 mm for upright maxillary implants (n = 84 implants) and 0.88 ± 0.59 mm for tilted maxillary implants (n = 42 implants). In the mandible, a mean peri-implant crestal bone loss of 0.82 ± 0.64 mm for upright implants (n = 32) and 0.75 ± 0.55 mm for tilted implants (n = 32) was found. No significant difference in crestal bone loss between tilted and upright implants was detected at the 12-month follow-up evaluation in either jaw.

## DISCUSSION

The clinical results of this study indicate that the rehabilitation of the completely edentulous maxilla and mandible with an immediately loaded full-arch fixed bridge anchored to tilted and upright implants may have a predictable outcome. The present data compare favorably with results published by Malò et al regarding the "All-on-4" protocol for the rehabilitation of the completely edentulous mandible[11] and other data for fixed full-arch immediately loaded maxillary rehabilitations supported by 2 axial and 2 tilted implants.[13]

Tilted implants may achieve the same outcome as implants placed in an upright position. This positive result is associated with biomechanical advantages, since in this protocol implants are placed in strategic positions from a load-sharing point of view. Placement of the 2 well-anchored posterior tilted implants together with the anterior upright implants can provide a predictable foundation for an implant-supported prosthesis.[17] This implant distribution along the maxillary or mandibular arch minimized the cantilever length, improving biomechanical load distribution. Furthermore, it may be easier to achieve a passive fit of the prosthesis with fewer implants than with a larger number of implants.

A protocol in which 4 or 6 implants are used, instead of the maximum possible number of implants, for the rehabilitation of a completely edentulous arch, is also supported by clinical documentation reporting that similar success rates have been achieved for fixed prostheses in both jaws using 4 or 6 implants.[18] Therefore, placing tilted implants in posterior jaws has a potential advantage over upright implant alignment. The head of the implant may be placed in a more favorable position with respect to load distribution, anchoring the implants in a denser bone and allowing the use of longer implants with respect to those used in the traditional surgical protocol involving only upright aligned implants.

Despite the biomechanical and the biologic advantages of these procedures from a surgical standpoint, there are a number of technical aspects that should be analyzed: *(a)* tilting implants in the maxillary posterior position should be done subsequent to anterior sinus wall localization; *(b)* detection of the anterior sinus wall requires additional surgical skill; *(c)* tilting

implants is limited by the ability of the patient to maintain maximal opening during placement.

In the mandibular arch, the procedure for the placement of a tilted implant is further complicated by the assessment of the mesial nerve loop extension. The latter can be validated by computerized tomography and by clinical intraforaminal probe insertion.

In the present study, only 5 patients were treated with this protocol in the first year. As confidence in the surgical procedure increased, more and more patients were recruited in the following years. It is recommended that this technique be adopted only by expert clinicians, as the surgical procedure requires surgical skills that can only be achieved with specific training.

In this clinical study, tilting of the implants did not affect the marginal bone resorption pattern. Only minimal differences that were not statistically significant between the upright and the tilted implants could be observed. This is in accordance with data obtained by other authors.[10,19,20]

## CONCLUSION

Placing implants in pre-existing bone enables avoidance of more complex surgical procedures such as maxillary sinus floor augmentation. The protocol adopted in the present study aimed at combining an optimized use of available bone with the benefits of immediate loading. According to the authors' experience, these methods led to more simple, more predictable, less expensive, and less time-consuming treatment compared to maxillary sinus augmentation.[21,22]

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