Partial Rehabilitation with Distally Tilted and Straight Implants in the Posterior Maxilla with Immediate Loading Protocol: A Retrospective Cohort Study with 5-Year Follow-up

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Purpose: The purpose of this study was to compare the outcome of fixed partial prostheses in the posterior maxilla with two axially placed implants or one implant placed distally tilted and one axially placed implant following an immediate loading protocol. Materials and Methods: A sample of 60 patients was divided into two groups—group 1: 30 patients rehabilitated with one axially placed implant and one implant placed distally tilted in the posterior maxilla; group 2: 30 patients rehabilitated with two axially placed implants in the posterior maxilla. Outcome measures were implant survival based on function, marginal bone resorption, and the incidence of mechanical and biologic complications at 5 years; inferential statistics were used to analyze the intergroup and intragroup differences. The level of significance was set at 5%. Results: No significant differences were found between both groups in survival, complications, or marginal bone resorption. One axially placed implant was lost at 58 months in group 1, rendering a cumulative survival estimate at 5 years of 96.7% and 98.3% in group 1 and the total sample, respectively (P = .317). Mechanical complications occurred in 16 patients (26.7%; n = 8 patients in each group; [P > .999]), consisting of fractures in the provisional prosthesis (n = 8 patients), chipped ceramics of the definitive prosthesis (n = 2 patients), loosening of prosthetic components (n = 5 patients), and fracture of an attachment screw (n = 1 patient). Biologic complications occurred in 5 patients (8.3%; group 1 = 4 patients; group 2 = 1 patient; [P = .161]), consisting of peri-implant pathology. The mean ± SD marginal bone loss was 2.02 ± 0.36 mm and 1.90 ± 0.69 mm for groups 1 and 2, respectively (P = .235). In group 1, the mean ± SD marginal bone loss was 1.92 ± 0.48 mm and 2.11 ± 0.44 mm for the implant placed distally tilted and axially placed implant, respectively; the difference was significant (P < .001). Conclusion: Within the limitations of this study, the use of implants placed distally tilted together with axially placed implants or two axially placed implants in the fixed partial rehabilitation of the posterior maxilla are viable treatment alternatives. Int J Oral Maxillofac Implants 2016;31:891–899. doi: 10.11607/jomi.4324

Keywords: biomechanical complications, fixed partial rehabilitation, immediate load, implant survival, marginal bone loss, tilted implants

The anatomy of the posterior maxilla is limited by the alveolar ridge and the maxillary sinus. The area configuration depends on factors such as the chronology, the cause of tooth loss, and previous treatments performed, affecting the pneumatization of the sinus, influencing the length, diameter, and inclination of the implant that is planned to be placed. The use of cone beam computerized tomography (CBCT) and the continuous evolution of implant dentistry led to the establishment of guidelines for the selection of the most adequate surgical technique for the rehabilitation of the posterior maxilla. The creation of these guidelines was meant to avoid overload factors, with
bending moments identified as the main overload cause, and to prevent the most frequent mechanical complications found in partial rehabilitations consisting of loosening of prosthetic components (abutment and attachment screw), and ceramic and abutment screw fracture. Numerous factors influence overload and should be taken into consideration, including the number of implants and distribution, implant diameter and length, the presence of cantilevers, the occlusion, the technologic characteristics of different elements, materials, and protocols; and the bone-to-implant support capacity. Load intervals were previously established to determine bone response to different stress magnitude: atrophy, 0 to 50 microdeformations (µε: unit of tension/deformation); regular bone modelation, 50 to 1,500 µε; overload, 1,500 to 3,000 µε.

The use of tilted implants was validated previously, with Krekmanov et al concluding that they had clinical and biologic advantages, such as improving cortical anchorage and primary stability, reducing the cantilever length, and gaining posterior support for better load distribution. The All-on-Four concept (Nobel Biocare) advocates the placement of two axially placed implants and two implants placed distally tilted for the reconstruction of edentulous arches. This rehabilitation technique registered survival rates between 95% and 97.6% for the maxilla and between 96% and 99% for the mandible. The placement of implants placed distally tilted up to a 45-degree angle derives from the necessity of avoiding anatomical limitations such as the mandibular nerve or the maxillary sinus, allowing for an immediate function protocol while preventing the need for more complicated techniques, such as bone grafts; or other treatment options including sinus elevation, short implants, tilted implants anchored in the tuberosity and pterygoid process, or zygomatic implants. Tilting may also allow the placement of a longer implant with bicortical anchorage (using the maxillary crest and nose corticals), reducing the cantilever and promoting more posterior support, increasing bone-to-implant contact, and reducing the stress on the alveolar crest.

Although bending moments are higher for tilted implants at the abutment level, the rigidity of the prostheses and the increased supporting prosthetic base keeps stress at acceptable levels.

This article focuses on the rehabilitation of the posterior maxilla through the use of an implant placed distally tilted and an axially placed implant in combination. The purpose of this study was to compare the 5-year outcome of fixed partial prostheses in the posterior maxilla with two axially placed implants or one implant placed distally tilted and one axially placed implant following an immediate loading protocol.

MATERIALS AND METHODS

This study was performed at a private practice, Malo Clinic, Lisbon, Portugal. It was authorized by an independent ethical committee (Ethical Committee for Health, authorization no. 005/2010).

The population consisted of patients submitted to implant-supported fixed partial prostheses in immediate function in the posterior maxilla, rehabilitated by the same clinical team, with a follow-up period of at least 5 years. Patients included in the study met the following criteria: need of a fixed partial prosthesis on the posterior maxilla and presence of sufficient mesiodistal space for the placement of at least two implants. A total of 60 patients were included (21 males and 39 females), with an average age of 64.1 years. The patients were rehabilitated between 1999 and 2009. The patients were divided into two groups: patients with fixed partial prostheses supported by one implant placed distally tilted and one axially placed implant (group 1) and two axially placed implants (group 2). The opposing dentition varied from natural teeth (n = 17 patients) to implant/tooth-supported fixed prostheses (n = 43 patients).

The majority of the cases involved the absence of three teeth, with the placement of the anterior and posterior implants in the position of the canine, first premolar, or second premolar; and second premolar, first molar, or second molar, respectively (Fig 1).

Surgical Protocol

The surgical protocol was described in length in a previous publication.

Surgical procedures were performed under local anesthesia with Mepivacaine Chlorhydrate with Epinephrine 1:100,000 (Scandinibsa 2%, Inibsa Laboratory). Every patient was medicated with antibiotics (amoxicillin 875 mg + clavulanic acid 125 mg, Labesfai) 1 hour prior to surgery and daily in the following 6 days; cortisone (prednisone 5 mg, Meticorten Schering-Plough Farma) was given daily in a regression mode (15 mg to 5 mg) from the day of the surgery until 4 days postoperatively; antiinflammatory (ibuprofen, 600 mg, Ratiopharm) was administered on the fourth day postoperatively; analgesics (clonixine [300 mg, Clonix, Janssen-Cilag Farmaceutica), were given on the day of surgery and on the subsequent 3 days, if necessary; antacid medication (omeprazole, 20 mg) was given on the day of surgery and daily for 6 days postoperatively.

Compromised teeth with caries, periodontitis, and periapical infections were extracted when needed at the time of surgery, before implant placement. A mucoperiosteal flap was raised with vertical relieving incisions in the first molar region. In the cases where an implant placed distally tilted was placed, a small orifice
The definitive ceramic or metal/ceramic fixed partial prostheses were manufactured and placed typically 4 to 6 months after surgery, with an occlusion mimicking natural dentition. Provisional prostheses remained for longer than 4 to 6 months in some patients due to financial reasons or patient convenience in scheduling the subsequent appointments.

Follow-up
Patients were evaluated postoperatively at 10 days, 2, 4, and 6 months, and every 6 months afterward, up to 5 years of follow-up. The fixed partial prostheses were removed at every maintenance appointment for clinical evaluation. In this study, patients were evaluated radiographically at baseline and at 5 years of follow-up for marginal bone resorption.

Outcome Measures
The primary outcome measure was prosthetic and implant success evaluated based on function. Implant success was further determined by fulfillment of the following criteria: clinical stability (absence of implant mobility evaluated by applying a lateral force), patient reported function without any discomfort, absence of suppuration (evaluated by applying finger pressure), absence of infection, or radiolucent areas around the implants at 5 years postsurgically.

Prosthetic Protocol
An impression was executed with soft putty immediately after the surgical procedure. After removing impression copings, abutment healing caps were attached to prevent mucosa from collapsing. After 3 hours, acrylic-resin fixed partial prostheses were connected. All crowns were adjusted to eliminate contact with antagonist teeth in excursive movements.

Implants placed distally tilted were inclined to a maximum of 45 degrees to avoid penetration into the maxillary sinus, to promote anchorage on the anterior wall of the sinus and the nasal floor, and to move the implant platform as posterior as possible (ideally to the first molar position). To compensate that inclination, 30-degree abutments (Multi-unit abutments, Nobel Biocare) were attached to the implants. The length of the posterior implants varied from 8.5 to 18 mm, while for the anterior implant, the length ranged from 7 to 15 mm. The diameter varied from 3.3 to 4 mm, for axially placed implants in anterior and posterior positions, and between 3.75 and 4 mm for implants placed distally tilted. After implant placement, the flap was repositioned and sutured with 3/0 silk suture (Silkam, B. Braun Aesculap), and impressions were taken.

was opened on the maxillary sinus with a round bur to identify the anterior wall. Underpreparation of the implant site was implemented to achieve an implant primary anchorage of at least 30 N/cm, allowing for immediate function. An angulation of 30 to 45 degrees in relation to the axially placed implant was considered for the implant placed distally tilted. Bicortical anchorage was achieved whenever possible.
Statistical Analysis

Descriptive analysis was used to classify the variables of interest. Implant survival was estimated using the Kaplan-Meier product limit estimator and the corresponding 95% confidence interval. Inferential analysis was used to test the significance of the differences between groups or inside a group. The Mann-Whitney test was used to evaluate the difference in marginal bone loss between both groups. The paired samples t test was used to evaluate the difference in marginal bone loss between the axially placed implant and the implant placed distally tilted in group 1. The chi-square test complemented by the Fisher exact test was used to evaluate the difference in the incidence of mechanical and biologic complications, and the distribution of nonsmoking patients between both groups. The level of significance was set at 5%. Statistical analysis was conducted using SPSS software (version 22.0, SPSS).

RESULTS

A total of 120 implants were placed, 30 implants placed distally tilted and 90 axially placed implants. The majority of the implants were placed in nonsmokers, 71.67% (n = 43), with a nonsignificant difference in the distribution between group 1 and group 2 (group 1 = 70%, group 2 = 76.7%; P = .771). The implants that were used varied in diameter and length. There were two Brånemark System MK II implants (Nobel Biocare) used with 3.75 mm of width and lengths of 13 mm (n = 1) and 15 mm (n = 1). Regarding the Brånemark System MK III (Nobel Biocare) implants, a total of 22 implants were used: 3.3 mm of width and lengths of 13 mm (n = 1), 15 mm (n = 2); 3.75 mm of width and lengths of 8.5 mm (n = 2), 13 mm (n = 2), and 15 mm (n = 10); 4 mm of width and lengths of 8.5 mm (n = 1), 13 mm (n = 2), and 15 mm (n = 2). Concerning the Brånemark System MK IV (Nobel Biocare), a total of 23 implants were used with 4 mm of width and lengths of 10 mm (n = 3), 11.5 mm (n = 1), 13 mm (n = 1), and 15 mm (n = 18). In relation to the NobelSpeedy Groovy (Nobel Biocare), a total of 72 implants were used: 3.3 mm of width and lengths of 10 mm (n = 1) and 15 mm (n = 1); 4 mm of width and lengths of 7 mm (n = 1), 8.5 mm (n = 4), 10 mm (n = 8), 11.5 mm (n = 4), 13 mm (n = 11), 15 mm (n = 35), and 18 mm (n = 7). One NobelReplace implant...
A tooth-implant supported fixed prosthesis was produced.

Mechanical Complications
Sixteen patients presented mechanical complications: eight patients in group 1 and eight patients in group 2, with a nonsignificant difference between both groups ($P > .999$). Eight patients experienced mechanical complications in group 1: three patients with fracture of the provisional prostheses (at 2, 6, and 7 months postsurgery); one patient with an attachment screw loosening (at 2 months); two patients with an abutment screw loosening (at 10 days and 2 months); one patient with an abutment and an attachment screw loosening (at 5 months); and 1 patient with chipping of (Nobel Biocare) was used with 3.5 mm of width and 15 mm of length.

Five prostheses had cantilever arms of one unit length, 2 in group 1 and 3 in group 2 (Table 1).

### Survival Analysis
One straight implant (maxillary left premolar; Nobel-Speedy Groovy 4 × 10 mm) was lost after 58 months in group 1, rendering a cumulative survival estimate at 5 years of 96.7%, 100%, and 98.3% for group 1, group 2, and overall, respectively (Table 2). Using the patient as the unit of analysis, the difference in implant survival between both groups was not significant ($P = .317$, Log-Rank test).

### Table 1 Prosthesis Design (Implant/Prosthesis Configuration)

<table>
<thead>
<tr>
<th></th>
<th>Cantilever (units)</th>
<th>Units per prosthesis</th>
<th>No. of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>0</td>
<td>3</td>
<td>25</td>
</tr>
<tr>
<td>(1 axial, 1 tilted implant)</td>
<td>1</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Group 2</td>
<td>0</td>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>(2 axial implants)</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

### Table 2 Survival of Implant-Supported Partial Rehabilitation in the Posterior Edentulous Maxilla Using the Patient as Unit of Analysis (First Implant Failure as Censoring Event)

<table>
<thead>
<tr>
<th>Time (mo)</th>
<th>Status (0 = survival; 1 = failure)</th>
<th>Cumulative proportion surviving at the time</th>
<th>No. of cumulative events</th>
<th>No. of patients at risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Estimate</td>
<td>Standard Error</td>
<td>No.</td>
</tr>
<tr>
<td>Total sample</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>24</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>36</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>48</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>58</td>
<td>1</td>
<td>0.983</td>
<td>0.033</td>
<td>1</td>
</tr>
<tr>
<td>60</td>
<td>0</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

| Group 1 (1 axial, 1 tilted implant) |        |          |                |     |                       |
| 0         | 0                                | 0        |                | 0   | 30                    |
| 12        | 0                                | 0        |                | 0   | 30                    |
| 24        | 0                                | 0        |                | 0   | 30                    |
| 36        | 0                                | 0        |                | 0   | 30                    |
| 48        | 0                                | 0        |                | 0   | 30                    |
| 58        | 1                                | 0.967a   | 0.033          | 1   | 29                    |
| 60        | 0                                | 1        |                | 1   | 29                    |

| Group 2 (2 axial implants) |        |          |                |     |                       |
| 0         | 0                                | 0        |                | 0   | 30                    |
| 12        | 0                                | 0        |                | 0   | 30                    |
| 24        | 0                                | 0        |                | 0   | 30                    |
| 36        | 0                                | 0        |                | 0   | 30                    |
| 48        | 0                                | 0        |                | 0   | 30                    |
| 60        | 0                                | 1        |                | 1   | 0                     |

Total and per group estimations (Kaplan-Meier product limit estimator).
aOne implant failed in one patient from group 1. The difference in survival estimation between both groups was not significant ($P = .317$, Log-rank test).

(Nobel Biocare) was used with 3.5 mm of width and 15 mm of length.

Five prostheses had cantilever arms of one unit length, 2 in group 1 and 3 in group 2 (Table 1).

**Mechanical Complications**
Sixteen patients presented mechanical complications: eight patients in group 1 and eight patients in group 2, with a nonsignificant difference between both groups ($P > .999$). Eight patients experienced mechanical complications in group 1: three patients with fracture of the provisional prostheses (at 2, 6, and 7 months postsurgery); one patient with an attachment screw loosening (at 2 months); two patients with an abutment screw loosening (at 10 days and 2 months); one patient with an abutment and an attachment screw loosening (at 5 months); and 1 patient with chipping of

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Kerr Group) and irrigation with 0.2% chlorhexidine gel and saline solution, with apical repositioning of the flap with suture for better hygiene and close contact to the underlying tissue. No further biologic complications occurred during the study period.

**Marginal Bone Loss**

Forty-six patients (77%) had readable radiographs for evaluating the marginal bone loss: 22 patients (73.3%) from group 1 and 24 patients (80%) from group 2 (Table 3). The mean ± SD marginal bone loss at 5 years was 1.96 ± 0.55 mm, 2.02* ± 0.36 mm, and 1.90* ± 0.69 mm for overall, group 1, and group 2, respectively. The difference in marginal bone loss at 5 years between both groups was not significant ($P = .235$).

Considering group 1, the mean ± SD marginal bone loss at 5 years was 2.11 ± 0.44 mm for axially placed implants and 1.92 ± 0.48 mm for implants placed distally tilted (Fig 3), with a significant difference between the types of implants ($P < .001$).

**DISCUSSION**

This study was conducted based on a clinical need for the rehabilitation of edentulism in the posterior maxilla. The intent was to simplify protocols to achieve immediate loading function even in the presence of very limiting anatomical conditions with the ultimate goal of satisfying patients in both the short and long term. The use of this treatment modality could imply that the performance of rehabilitation procedures that

does not apply

the ceramic in the definitive prosthesis (at 14 months). Eight patients experienced mechanical complications in group 2: five patients with fractured provisional prostheses (at 10 days, 1 month, 4 months, 11 months, and 17 months); one patient with chipped ceramics at 41 months; one patient with a fractured attachment screw at 55 months; and one patient with a loose abutment screw at 8 months.

All resolutions of the mechanical complications involved an adjustment of the occlusion. Furthermore, the fractures of the provisional prostheses were resolved by mending the prostheses; the loosening of prosthetic elements was further resolved by retightening the elements; the chipping of ceramics was further resolved chairside with composite resin; and the fractured attachment screw was replaced.

**Biologic Complications**

Five patients presented biologic complications (8.3%), with four events in group 1 (13.3%) and one event in group 2 (3.3%), with a nonsignificant difference between groups ($P = .161$).

In group 1, three patients presented peri-implant pathology with peri-implant pockets of 5 mm, and one patient presented a peri-implant pocket of 9 mm. In group 2, one patient presented a peri-implant pocket of 5 mm. The 5-mm peri-implant pockets in the four patients were resolved nonsurgically through scaling and irrigation with 0.2% chlorhexidine gel, while the 9-mm peri-implant pocket was resolved surgically: a flap was raised for removal of granulation tissue around the implant with implant deplaquers (Kavo Kerr Group) and irrigation with 0.2% chlorhexidine gel and saline solution, with apical repositioning of the flap with suture for better hygiene and close contact to the underlying tissue. No further biologic complications occurred during the study period.

<table>
<thead>
<tr>
<th>Bone loss (mm)</th>
<th>Overall (Mean ± SD)</th>
<th>Group 1 (1 axial, 1 tilted implant)</th>
<th>Group 2 (2 axial implants)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 mm</td>
<td>0.0 ± 0.0%</td>
<td>0.0 ± 0.0%</td>
<td>0.0 ± 0.0%</td>
</tr>
<tr>
<td>0.1–1.0 mm</td>
<td>2.4 ± 0.4%</td>
<td>0.0 ± 0.0%</td>
<td>2.8 ± 0.3%</td>
</tr>
<tr>
<td>1.1–2.0 mm</td>
<td>43.5 ± 0.5%</td>
<td>8.3 ± 0.3%</td>
<td>12.5 ± 0.5%</td>
</tr>
<tr>
<td>2.1–2.5 mm</td>
<td>41.2 ± 1.3%</td>
<td>14.6 ± 3.4%</td>
<td>5.2 ± 0.6%</td>
</tr>
<tr>
<td>2.5–3.0 mm</td>
<td>6.5 ± 0.7%</td>
<td>0.0 ± 0.0%</td>
<td>3.1 ± 1.2%</td>
</tr>
<tr>
<td>&gt; 3.0 mm</td>
<td>2.4 ± 0.4%</td>
<td>0.0 ± 0.0%</td>
<td>2.8 ± 0.3%</td>
</tr>
</tbody>
</table>

*The difference between both groups was not significant ($P = .369$).
are technically more complex and with higher morbidity such as bone grafting are only justifiable within the impossibility of executing simpler interventions. Esposito et al reported an absence of statistically significant differences in the loss of implants in scenarios of immediate function and with a conventional protocol. This study relied partially on the fundamentals of full-arch rehabilitation performed following the All-on-Four concept. Despite the differences in biomechanics between full-arch and partial rehabilitation, tilting the posterior implant was previously demonstrated to offer a biomechanical advantage compared with axial implants when a cantilever is needed, by reducing the cantilever arm and increasing the prosthesis support area. As reported in this study, two prostheses with four units presented a cantilever of one unit with a tilted posterior implant. Moreover, according to Greenstein et al, prostheses with cantilevers, supported by implants with angled abutments, do not demonstrate lower success rates in the absence of high stress, compared with axial implants. Additionally, Eliasson et al registered a nonsignificant difference in the incidence of mechanical complications between partial rehabilitations with two and three implants while reporting survival rates of 96.8% and 97.6%, respectively. Based on the previous assumptions, the authors attempted to investigate if the evidence found for full-arch prostheses with tilted and straight implants could be replicated to fixed partial prostheses. The present study registered good outcomes for fixed partial prostheses in the posterior maxilla using two straight implants or a combination of one straight anterior implant and one distally tilted posterior implant. Previous clinical studies also registered good outcomes for partial rehabilitations, with Agliardi et al and Aparicio et al reporting implant survival rates of 100% at 50 months and 98.25% at 5 years, respectively. Furthermore, the results of this study compare favorably to the previous meta-analysis by Lindh et al, comprising 10 studies on fixed partial prostheses using straight implants, where a cumulative survival rate of 93.8% was estimated after a follow-up of 5 years. Implant tilting did not demonstrate a detrimental effect on the survival outcome of the patients in the present study, a result that is supported by previous studies. Aparicio et al reported cumulative survival rates of 96.5% and 100% for straight and tilted implants, respectively, at the end of a period of 5 years. Calandriello et al registered a cumulative survival rate of 97% and 96.3% at 1 year for tilted implants and straight implants, respectively. It was suggested that this difference might be associated with the use of longer implants taking advantage of cortical bone, with tricortical anchorage usually obtained to support the implant by using the nose cortical, the alveolar crest, and the mesial wall of the maxillary sinus.

Krekmanov et al observed that the use of tilted implants did not constitute a biologic disadvantage, registering a higher failure rate for straight implants compared with tilted implants (6 implant failures and 1 implant failure, respectively, in a total of 138 implants placed). Krekmanov et al's strain gauge measurements registered no significant differences in bending moments and stress produced by axial forces in straight and tilted implants for the same prostheses, which suggests that the rigidity of the structure decreases the force transferred to the implants. Also, the position of the implant platform is more important than the implant being tilted or axial.

Similarly, Jemt et al registered a cumulative implant survival rate of 97.2% at 5 years; however, a high frequency of mechanical complications was reported, with 29 of 58 patients (50%) experiencing mechanical complications in which the partial prostheses involved were removed 65 times for various adjustments. Another study from Aparicio et al also registered a 55.2% rate of mechanical complications, with acrylic fracture and abutment loosening as the most frequent mechanical complications, comparable to the present study; nevertheless, the lower frequency of mechanical complications (26.7%) registered in the present study data. The low frequency of ceramic fractures (3.3%), with only two patients fracturing their definitive prostheses (one in each group), demonstrates the efficacy of this material, a result that was lower compared with the 14% registered in a systematic review by Pjetursson et al at 5 years.

Biologic complications can affect soft and hard tissues around implants, ranging from 7% to 20%, according to different studies. The difference found in the distribution of biologic complications for both groups was not significant. Testori et al reported no complications associated with the use of tilted implants in the rehabilitation of the atrophic maxilla after 1 year. Pjetursson et al, on the other hand, found a cumulative incidence of peri-implantitis and soft tissue complications of 8.6% at 5 years for fixed partial prostheses, similar to the 8.3% rate presented by this study, even though there is no reference as to whether the implants used were tilted or not.

The present study registered a significantly lower marginal bone loss at 5 years for implants placed distally tilted compared with axially placed implants in group 1. Several studies reported comparable or favorable mean marginal bone loss for tilted implants compared with straight implants. Monje et al presented similar results in a meta-analysis, reporting a nonsignificant variation of 0.054 mm (P = .207) in the marginal bone loss between straight and tilted
implants favoring the tilted implant group. Del Fabbro et al.\(^{19}\) did not register significant differences for marginal bone loss between straight and tilted implants, suggesting this could be related to the position of the tilted implant neck relative to bone crest: Mesially, the neck was in a supracrestal position, while distally, it was positioned subcrestally, resulting in a favorable soft tissue seal. A meta-analysis from Chrcanovic et al.\(^{20}\) registered that the insertion of dental implants in a tilted position did not statistically affect the implant failure rates or the marginal bone loss in relation to axially placed implants. Furthermore, Aparicio et al. registered nonsignificant differences between marginal bone measures for tilted and axial implants over the course of 5 years.

Studies\(^{2,10,12,32,40,51}\) on posterior fixed partial prostheses in the maxilla revealed the absence of important information such as smoking habits and opposing dentition. Despite considering the information that was missing in other studies and the 5 years of follow-up that accounts as strengths of the present study, there were also limitations, including being performed in a single center, the convenience sampling, and the lack of randomization for allocating the patients to both groups. A further limitation represents the approximately 20% of nonreadable radiographs, which might influence the marginal bone loss analysis.

Prospective clinical studies with multivariable analyses, larger samples, and longer follow-up are needed to clarify the long-term outcome of fixed partial prostheses supported by implants in immediate function. Finite element analytical studies are essential and needed to verify the effect on each implant of axial and lateral forces, applied to different points along the fixed partial prostheses.

**CONCLUSIONS**

Considering the results, the use of an implant placed distally tilted together with an axially placed implant in fixed partial prostheses for the rehabilitation of the posterior edentulous maxilla is a viable treatment alternative even in the presence of anatomical limitations that disable the placement of a posterior axially placed implant. At 5 years, the use of implants placed distally tilted did not compromise the outcome of fixed partial rehabilitations, judging by the nonsignificant differences registered in the incidence of biologic complications, mechanical complications, and marginal bone loss compared with fixed partial rehabilitations using two axially placed implants.

**ACKNOWLEDGMENTS**

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**REFERENCES**


