ABSTRACT

Background: Wide implants are recommended as “rescues” after failure to increase primary stability in extraction sockets or in poor quality bone. Consequently, inferior results compared with regular diameter implants have been reported.

Purpose: The purpose of this study was to evaluate retrospectively the outcome of a novo wide-body implant (Max® implant, Southern Implants®️, Irene, South Africa) designed for placement in the posterior regions.

Materials and Methods: In four private practices, patients with at least one Max implant were examined by two independent examiners to determine implant survival and marginal bone loss. Surgical, prosthetic, and patient-related parameters were evaluated to determine their influence on the treatment outcome.

Results: Seventy-five patients (31 male, 44 female), with a mean age of 58 years, received 93 Max implants (59 maxilla, 34 mandible) of 8 to 10 mm width. Twenty-seven implants in molar extraction sockets and two in mature bone were immediately loaded; 42 in extraction sockets and 22 in mature bone were delayed loaded. The mean follow-up was 14 months (6–34), and four implants failed (4.3%); mean bone loss after 1 year was 0.46 mm (SD 1.08; range $-5.45$–$3.25$). A total of 91.4% lost <1.5 mm of bone during the first year. The implant survival rate was 89.7% and 98.4%, respectively, for the immediate and delayed loaded implants and 95.8% and 95.7% for delayed and immediate placement. Time of placement, time of loading, surgical protocol, or prosthetic design did not affect the outcome.

Conclusion: Within the limitations of the study, the Max implant demonstrated a survival rate of 95.7% and stable bone conditions after a year, irrespective of loading or surgical protocol. Future prospective studies are needed to evaluate the soft and hard tissue changes in time.

KEY WORDS: dental implant, immediate loading, immediate placement, posterior region, wide body, wide diameter

INTRODUCTION

Several studies report high long-term success rates with endosseous implants.¹⁻³ Success rates depend on many factors, such as anatomic and loading conditions, surgical protocol, implant features, and patient-related factors.⁴⁻⁹ The posterior region of the upper and lower jaw is considered a risk zone for implant treatment because of the higher occlusal forces, poorer bone quality, and often limited bone quantity.¹⁰,¹¹ The position of the maxillary sinus and mandibular nerve often complicates the treatment plan by limiting the available bone height. Rather than going for advanced surgical treatments, such as sinus lifting or mandibular nerve repositioning, placement of a shorter implant is preferable.¹² To compensate for the reduced implant length, the option may be to increase the bone-to-implant contact area by placing a wider implant.¹³⁻¹⁵ This
enhances bicortical stability, increases the surface for osseointegration,16,17 and enhances primary stability and facilitates the osseointegration process.18–20 Therefore, the wide-body implant was initially introduced to be used in cases with insufficient bone height, poor bone quality, or as a rescue implant.21 A “wide” implant is generally defined as 4.5 mm diameter or more.12 Implant diameter is the dimension measured from the peak of the widest thread to the same point on the opposite side of the implant.22 Early publications on wide-diameter implants reported an increased failure rate compared with regular diameter implants. Shin and colleagues17 reported in a retrospective study survival rates of 80.41% and 96.8% for wide- and regular-body implants, respectively. Eckert and colleagues13 also found statistically higher failure rates for wide-body implants in both maxilla and mandible. Both studies found a correlation between the available bone volume and implant survival.13,17 According to the authors, a critical bone volume was needed for osseointegration, which was sometimes hampered by wide-diameter implants. In general, the wide-body implants with a turned titanium surface demonstrated failure rates of 9 to 24%,13,14,17,23

The fact that, especially in the early studies, most failures were reported before 2-stage surgery indicates that the reason for failures is probably related to the surgical protocol, the indication, the design of the implant, and the degree of initial stability obtained after implant placement.14 Others have consistently reported failure rates of less than 5% up to 5 years of function.24–27 A modified moderate rough surface and adapted surgical protocol and implant design may promote the anchorage in the bone and decrease implant failures.12,28

Wide-diameter implants are often used to be placed immediately in extraction sockets because they increase stability by reaching the socket wall.21,22,28 Grunder and colleagues29 experienced failure rates of 11.1% and 5.2% when implants were placed immediately or immediately delayed in the posterior maxilla and mandible. Penarrocha-Diago and colleagues30 compared the outcome of immediate and delayed placement in molar sites. Their study revealed no differences in implant survival between the delayed and immediate placement group (96.9% vs 100%), but less peri-implant bone loss was reported for the immediately placed implants (0.6 mm vs 0.89 mm). Gomez-Roman and colleagues31 reported survival rates of 99% and 97%, respectively, after 1 year and 6 years for immediately placed implants in both the anterior and posterior jaw with a bone loss of 0.8 mm. Other studies reported survival rates of 92.7 to 100% and concluded that immediate implant placement is highly predictable.32–36

The increased implant stability, because of the increased contact surface, offers possibilities for immediate loading. Recent studies have shown good results with immediate loading in the posterior jaw, reporting survival rates between 85.5% and 100%. Luongo and colleagues37 reported 98.8% survival and 0.52 mm peri-implant bone loss after 1 year when implants were immediately loaded in partially edentulous posterior maxilla and mandible. Abboud and colleagues38 experienced no implant failures with immediately loaded implants replacing a single molar. Bone loss was only 0.01 mm.

A few studies compare immediate loading with delayed loading in the posterior jaw. Schincaglia and colleagues39 reported one implant failure (implant survival rate 93.3%) of an immediately loaded implant and no failures in the delayed loading group (implant survival rate 100%) after 1 year. More bone loss was observed around the delayed loaded implants (0.77 mm vs 1.2 mm). Romanos and Nentwig40 found no differences in implant failure rate (100% implant survival) or interproximal bone loss after 2 years when implants were loaded immediately or delayed.

Some authors tried to compare immediate and early loading in the posterior mandible and maxilla. Zöllner and colleagues41 compared the outcome of immediately and early loading with a provisional single tooth or fixed partial denture (FPD). After 5 months, respectively 98% and 97% of the implants survived in the immediately and early loading group, and bone loss was respectively 0.81 mm and 0.56 mm, a difference that was center dependent. After 1 year, bone loss was respectively 0.90 mm and 0.63 mm, and bone gain was observed in 16% of the implants.42 Achilli and colleagues43 found no differences in survival rate (100%) and bone loss (1.24 mm vs 1.19 mm) after 1 year between the immediately and early loaded implants.

Other advantages of wide-diameter implants are the more favorable distribution of occlusal forces and the opportunity to use wider and stronger prosthetic components.44 The latter allows higher torque forces, reduces screw loosening, and decreases the risk for technical complications.
The aim of this retrospective, multicenter study was to evaluate the treatment outcome of a novo wide-body implant (Max® implant, Southern Implants®, Irene, South Africa) placed in healed bone or in extraction sockets in the posterior jaw.

MATERIALS AND METHODS

Implant Design
The Max implants are 8 mm, 9 mm, or 10 mm wide and 7 to 13 mm long, with a 0.8 mm thread pitch. They have an external hex and a moderately rough surface created by sandblasting and acid etching of a grade 4 CP titanium. Because of the wide diameter, there is a platform shifting of 0.25 mm on the horizontal and a further 0.35 mm at 45°. Figure 1 shows details of the implant design. The diameter 9 implant is 1 mm bigger, the prosthetic components are wider, and hence, the platform shifting is exactly the same. Figure 2 summarizes the clinical procedure using a Max implant in an immediate placement.

Data Collecting and Patient Selection
In total, four private pilot clinics (A.A., A.T., A.H., J.B.) participated in this multicenter study. Consecutively treated patients were encouraged to participate in the study and were asked to attend a clinical examination by an independent multidisciplinary team of researchers of the University of Ghent, Belgium. Patients were selected depending on their availability and with a loading time close to 1 year. This study was approved by the Ethical Committee of the University Hospital Ghent, Belgium.

Implant data were collected from patient files and clinical examination. Surgical parameters were time of placement, time of loading, one- or two-stage surgery, using a bone graft, implant position, and implant dimensions. Patient-related parameters were smoking and gender. Immediate loading was defined as “functionally loaded within 72 hours”; delayed loading was defined as “functionally loaded after at least 3 months.” Delayed placement was defined as “implant placement at least 6 months after tooth extraction.”

The implant prosthetics were categorized into four groups: single crowns, FPDs, fixed cross-arch bridges, and overdentures. Also, plaque and bleeding were assessed.

Radiographic Analyses
During examination, periapical radiographs were taken to determine the peri-implant bone level. For all examined implants, a baseline radiograph taken after surgery was available. Radiographic analyses were carried out by one independent examiner (S.V.D.W.) not involved in

Figure 1  The Max implant design. It has a small smooth collar and a platform shift of 0.25 mm in the horizontal plane and 0.35 mm at the bevel. A, Horizontal platform; B, bevel; C, implant body diameter; D, implant neck diameter; E, implant platform diameter; F, prosthetic diameter; G, thread pitch.
Figure 2 First maxillary molar with a large defective filling and periapical infection that justified tooth extraction (A–C). The roots were sectioned and atraumatically removed to avoid damage to the surrounding bone (D and E). During implant bed preparation, the interradicular septum is removed (F). The implant is installed after pretapping of the bone to avoid too much friction, and the residual space is filled with a bone-grafted material (G). A healing abutment is placed followed by flap adaptation and suturing (H). The implant is placed slightly deeper to compensate for the bone resorption foreseen to occur after extraction because of biological width and postextraction remodeling (I). Radiographic and clinical situation of the screw-retained crown after 8 months of loading, revealing stable bone and peri-implant contour. The body of the implant tapers significantly as there are only “islands” of bone in the multi-rooted sockets. The significant taper helps achieve implant stability even when less than half of the implant body is in contact with bone (J–L).

The initial implant treatment using DBSWIN software (Dürr Dental AG, Bietigheim-Bissingen, Germany) with an accuracy of 0.1 mm. Radiographs were calibrated using the known thread pitch as a reference. Bone level was determined from implant/abutment connection to the first bone-to-implant contact mesially and distally. The mean of both values was taken as the implant bone level. The actual bone loss or bone gain was calculated as the difference between baseline and at follow-up. Figure 3 gives an example of the bone loss calculation.

Each individual implant was dichotomized as either a success (value 1) or a survival (value 0) for
Kaplan-Meier analysis. Implants up to 1 year in function were called “implant bone loss success” when bone loss during the first year was \( \leq 1.5 \text{ mm} \); implants longer than 1 year in function were successful when bone loss was \( \leq 1.5 + 0.2 \times \text{[time in months – 12]}/12 \) mm, based on the internationally accepted criteria of Albrektsson and Isidor, allowing a maximum 1.5 mm bone loss during the first year and 0.2 mm yearly thereafter.

Statistics were performed with SPSS v16 for Windows (SPSS Inc., Chicago, IL, USA). Mann-Whitney \( U \) test was used for bone loss analyses. Fisher’s exact test was used for statistical comparison of implant failure and success rate.

RESULTS

Patient and Implant Distribution

A group of 75 patients (31 male, 44 female), with a mean age of 58 years (SD 11.69; range 25–82), were available for clinical examination. Ten out of 75 patients were smokers, with 6 being light smokers (less than 10 cigarettes a day) and 4 being heavy smokers (more than 10 cigarettes a day). Ninety-three Max implants (Southern Implants) were placed: 59 in the maxilla, 34 in the mandible. Implant diameter varied between 8 mm and 10 mm, while the implant length ranged from 7 mm to 13 mm. The implant distribution according to position and size can be seen in Figure 4 and Table 1.

Surgical Protocol

An overview of all surgical parameters with their corresponding number of implants and outcome can be seen in Table 2. All 29 implants in the immediate loading group were part of fixed cross-arch bridges and functionally loaded. An overview of all implants with their corresponding placement and loading protocol can be seen in Table 3.
Around 17 implants, some sort of bone grafting had been carried out. In 15 cases (16.1%), Bio-Oss® (Geistlich Pharma AG, Wolhusen, Switzerland) was used; in 1 case (1.1%), autogenous bone was used for a sinus graft; and in 1 other case (1.1%), a combination of Bio-Oss and autogenous bone was used to lift the sinus. Fifteen out of 17 (88.2%) cases of bone grafting was carried out in combination with immediate placement, which means that 21.7% of the extraction cases were carried out using some kind of bone graft.

Implant Failure
Table 2 shows all examined surgical and patient-related parameters with their corresponding survival rates. The mean follow-up period was 14 months (SD 5.73; range 6–34). Four out of 93 implants failed, resulting in a survival rate of 95.7%. Three failures were in extraction cases in conjunction with immediately loading, and two of these were because of inclusion of impression material in the extraction socket. There were no statistically significant differences in implant survival rates.

Bone Loss and Corresponding Implant Success
The mean bone loss, with an average of 14 months in function ($n = 89$; SD 5.73; range 6–34) calculated from time of abutment placement, is 0.46 mm (SD 1.08; range $-5.45–3.25$). Taking only the implants with at least 1 year of function, the mean bone loss was 0.53 mm (SD 0.85; range $-1.65–3.25$) after a mean follow-up time of 16 months (SD 5.26; range 12–34). Kaplan-Meier survival shows that a steady bone level is reached during the second year (Figure 5). As can be derived from Table 2, there are no statistically significant differences in any of the different surgical or patient-related parameters. Also, no correlation was found between any of the prosthetic parameters and peri-implant bone loss (Table 4).

In total, 91.4% of the implants were successful according to the applied criteria$^{46}$; four implants survived (4.3%) but lost more bone than accepted, and four implants failed (4.3%). The bone loss success rates for immediate loading (86.2%) and immediate placement (89.9%) were slightly lower than for delayed loading (93.5%) and delayed placement (95.8%), although not statistically significantly different. As can be seen in Tables 2 and 4, there were no statistically significant differences in implant success rates between the different examined parameters.

Prosthetic Restorations
In total, 87 Max implants were loaded, 2 were not yet in function and 4 had failed. Twenty-seven implants supported single crowns; respectively 35, 24, and 1 Max implants were part of multi-implant FPD, cross-arch bridge, and overdenture. Of all implants with a fixed restoration, 87.2% supported a construction with porcelain teeth, 10.5% supported a construction with acrylic teeth, and 2.3% supported gold single crowns. A total of 72.1% were screw-retained (65.1% on implant level, 7.0% on abutment), and 27.9% were cemented.

Peri-Implant Condition
Plaque and bleeding levels were evaluated according to Mombelli and colleagues$^{45}$ and are presented in Figure 6. Although peri-implant probing depths were initially included in the examination protocol, these were considered invalid because of touching the implant shoulder instead of the actual peri-implant sulcus/pocket. Hence, they are not reported. No signs of heavy inflammations, reflected, for example, by pus evacuation, were observed, and the clinical condition of the natural teeth as well as the implants was described as good to perfect.

DISCUSSION
In the current study, 95.7% of the implants survived when used under various indications and by various
<table>
<thead>
<tr>
<th></th>
<th>Number of Implants (%)</th>
<th>Survival % (Failures)</th>
<th>p Value (Fisher’s Exact Test)</th>
<th>Mean Bone Loss (mm)</th>
<th>p Value (Mann-Whitney U Test)</th>
<th>Implant Bone Loss Success %</th>
<th>p Value (Fisher’s Exact Test)</th>
<th>Time (Months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number</td>
<td>93 (100)</td>
<td>95.7 (4)</td>
<td></td>
<td>0.46 (SD 1.08; range −5.54−3.25)</td>
<td></td>
<td>91.4</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>Maxilla</td>
<td>59 (63.4)</td>
<td>94.9 (3)</td>
<td>1.000</td>
<td>0.46 (SD 0.98; range −2.75−2.70)</td>
<td>.705</td>
<td>91.5</td>
<td>1.000</td>
<td>14</td>
</tr>
<tr>
<td>Mandible</td>
<td>34 (36.6)</td>
<td>97.1 (1)</td>
<td></td>
<td>0.46 (SD 1.14; range −5.45−3.25)</td>
<td></td>
<td>91.2</td>
<td>1.000</td>
<td>14</td>
</tr>
<tr>
<td>1-stage</td>
<td>64 (68.8)</td>
<td>95.3 (3)</td>
<td>1.000</td>
<td>0.40 (SD 1.19; range −5.45−3.25)</td>
<td>.411</td>
<td>90.6</td>
<td>1.000</td>
<td>14</td>
</tr>
<tr>
<td>2-stage</td>
<td>29 (31.2)</td>
<td>96.6 (1)</td>
<td></td>
<td>0.59 (SD 0.78; range −1.65−2.05)</td>
<td></td>
<td>93.1</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>Immediate functional loading</td>
<td>29 (31.2)</td>
<td>89.7 (3)</td>
<td>.094</td>
<td>0.25 (SD 1.50; range −5.45−2.00)</td>
<td>.926</td>
<td>86.2</td>
<td>.260</td>
<td>13</td>
</tr>
<tr>
<td>Delayed loading</td>
<td>62 (66.6)</td>
<td>98.4 (1)</td>
<td>1.000</td>
<td>0.55 (SD 0.85; range −1.65−3.25)</td>
<td>.984</td>
<td>93.5</td>
<td>.260</td>
<td>14</td>
</tr>
<tr>
<td>Unloaded</td>
<td>2 (2.2)</td>
<td>100 (0)</td>
<td></td>
<td>0.50 (SD 0.28; range 0.30−0.70)</td>
<td></td>
<td>100</td>
<td></td>
<td>18</td>
</tr>
<tr>
<td>Healed bone</td>
<td>24 (25.8)</td>
<td>95.8 (1)</td>
<td></td>
<td>0.61 (SD 0.63; range −0.40−1.50)</td>
<td>.436</td>
<td>95.8</td>
<td>.675</td>
<td>13</td>
</tr>
<tr>
<td>Extraction socket</td>
<td>69 (74.2)</td>
<td>95.7 (3)</td>
<td>1.000</td>
<td>0.41 (SD 1.19; range −5.45−3.25)</td>
<td></td>
<td>89.9</td>
<td>.675</td>
<td>14</td>
</tr>
<tr>
<td>Nongrafted site</td>
<td>76 (81.7)</td>
<td>96.1 (3)</td>
<td></td>
<td>0.45 (SD 1.11; range −5.45−2.70)</td>
<td>.560</td>
<td>92.1</td>
<td>.675</td>
<td>13</td>
</tr>
<tr>
<td>Grafted site</td>
<td>17 (18.3)</td>
<td>94.1 (1)</td>
<td>.561</td>
<td>0.52 (SD 0.96; range −0.65−3.25)</td>
<td></td>
<td>88.2</td>
<td>.635</td>
<td>16</td>
</tr>
<tr>
<td>Smokers</td>
<td>12 (12.9)</td>
<td>100 (0)</td>
<td></td>
<td>0.38 (SD 1.11; range −5.45−3.25)</td>
<td>.205</td>
<td>91.7</td>
<td>.205</td>
<td>18</td>
</tr>
<tr>
<td>Nonsmokers</td>
<td>81 (87.1)</td>
<td>95.1 (4)</td>
<td>1.000</td>
<td>0.48 (SD 0.82; range −0.30−2.70)</td>
<td></td>
<td>91.4</td>
<td>.100</td>
<td>13</td>
</tr>
<tr>
<td>Male</td>
<td>40 (43)</td>
<td>95 (2)</td>
<td></td>
<td>0.25 (SD 1.32; range −5.45−1.60)</td>
<td>.531</td>
<td>95</td>
<td>.459</td>
<td>13</td>
</tr>
<tr>
<td>Female</td>
<td>53 (57)</td>
<td>96.2 (2)</td>
<td>1.000</td>
<td>0.62 (SD 0.83; range −0.65−3.25)</td>
<td></td>
<td>88.7</td>
<td>.459</td>
<td>14</td>
</tr>
</tbody>
</table>
clinicians under “real-life” conditions. This result is comparable with other wide-body implants in the posterior region. The conical design of the Max implant has the advantage that the bone is gradually increasing in thickness toward the apex of the implant, which may be advantageous especially with respect to blood supply in the buccal bone plate.

Several authors report better results in the maxilla than in the mandible. It is therefore important to carefully perform surgery in posterior mandibles in order to preserve and optimally use the existing dense bone. Only one study by Mordenfeld and colleagues reported 78.3% survival in the maxilla, compared with 94.5% in the mandible. In the current study, no statistically significant difference was observed between the maxilla and the mandible probably related to the design features of the implant.

Some authors report more peri-implant bone loss around wide-diameter implants compared with standard diameter implants. The amount of bone loss observed in the current study is very low and only 0.46 mm after more than 1 year. Considering the implants with at least 1 year function time, the bone loss is 0.53 mm, which is far within the criteria for success and according to other studies. Our findings show that bone loss around the Max implant is comparable with bone loss on regular-diameter Southern Implants with the same surface. The superior outcome of bone preservation under the challenging conditions the implants had been used at is because of the specific implant design. The stress reduction in the cortical bone, because of the slightly reduced coronal diameter, may prevent marginal bone loss. Also, the large difference in implant and prosthetic diameter, creating a large platform-switch effect, may have affected bone loss. The latter aspect is, however, currently under debate, and prospective, randomized control studies are still lacking to proof this principle.

<table>
<thead>
<tr>
<th>Loading</th>
<th>Healed Bone (%)</th>
<th>Extraction Socket (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate</td>
<td>2 (2.2)</td>
<td>27 (29.0)</td>
<td>29 (31.2)</td>
</tr>
<tr>
<td>Delayed</td>
<td>21 (22.6)</td>
<td>41 (44.1)</td>
<td>61 (66.7)</td>
</tr>
<tr>
<td>Unloaded</td>
<td>1 (4.2)</td>
<td>1 (1.4)</td>
<td>2 (2.2)</td>
</tr>
<tr>
<td>Total</td>
<td>24 (25.8)</td>
<td>69 (74.2)</td>
<td>93 (100)</td>
</tr>
</tbody>
</table>

**Figure 5** Kaplan-Meier curve based on estimated bone loss in time (“Success curve”) using the criteria of Albrektsson and Isidor and based on implant failure (“Survival curve”), with the implant as the statistical unit.
Tooth extraction results in a reduction of the bone quantity, which may prevent placement of an implant because of the decreased bone volume. Therefore, some authors advocated immediate placement, although others say that immediate placement does not prevent the natural bone resorption, which is part of the healing process after tooth extraction. The wide diameter of the Max implant was intended to provide good initial stability when placed in molar extraction sockets. Although one study reports less bone resorption when wide implants were placed immediately, most studies found no difference in survival rate. This corresponds with the findings from the current study, indicating no difference in survival rate or bone loss between immediate and delayed placement. Immediate post-extraction placement requires from the surgeon insight in the normal healing process. Placement should foresee bone remodeling, hence, a deeper placement of the implant to avoid thread exposure may be necessary (see Figure 2). This is also recommended by the clinicians involved in this study.

Few studies compared the influence of loading time on treatment outcome. One study reported less bone loss in favor of the immediately loaded implants compared with delayed loading. Another study comparing immediate and early loading found more bone loss around immediately loaded implants. Although the survival rate and peri-implant bone loss for delayed loaded implants were higher in the current study compared with the immediately loaded implants, these differences were not statistically significant. Hence, it can be concluded that the immediate loading of Max implants has no adverse effect on the treatment outcome. However, two of the failures in the immediate loading group were iatrogenic in nature because of the inclusion of impression material into the residual space of the extraction socket around the implant. Clinicians should be warned that the use of a rubber dam is required when taking impressions in conjunction with immediate implant placement.

**CONCLUSION**

That four different surgeons were involved and the data were collected and analyzed retrospectively can be responsible for the fact that none of the parameters seemed to affect the treatment outcome and may limit the validity of the current study. Nevertheless, with a 95.7% survival rate, 0.46 mm bone loss, and 91.4%
success rate using strict criteria, the Max implant is comparable with other wide-body implants. The implant functioned well when immediately placed in extraction sockets, but caution is advised regarding immediate loading. Further prospective studies in different indications are necessary to confirm these results.

ACKNOWLEDGMENT

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