Wide-Diameter Implants: Analysis of Clinical Outcome of 304 Fixtures

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Background: In the last decade, the use of wide-diameter implants (WDIs; diameter >3.75 mm) has increased. Although good clinical outcomes have been reported in recent literature, there are few reports on this topic. Thus, we planned a retrospective study on a large series of WDIs to evaluate the clinical outcome.

Methods: From October of 1996 to December of 2004, 205 patients were operated on, and 304 WDIs were inserted. The mean postloading follow-up was 30 months. Implant diameter and length ranged from 5.0 to 6.5 mm and from 8.0 to 15 mm, respectively. Because only five of 304 implants were lost (i.e., a survival rate of 98.4%) and no statistical differences were detected among the studied variables, no or reduced crestal bone resorption (CBR) was considered an indicator of success to evaluate the effect of several host-, surgery-, and implant-related factors. A general linear model (GLM) was performed to detect variables that were associated statistically with CBR.

Results: Only five of 304 WDIs were lost, and no differences were detected among the studied variables. On the contrary, the GLM showed that distal teeth (i.e., premolars and molars), small implant diameter (i.e., 5.0 and 5.5 mm), and short implant length (i.e., <13 mm) correlated with a statistically significant lower CBR.

Conclusion: The use of WDIs is a viable treatment option, and it may provide benefits in posterior regions for long-term maintenance of various implant-supported prosthetic rehabilitations. *J Periodontol 2007;78:52-58.*

KEY WORDS

Implants; linear model.

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In the last decade, the use of wide-diameter implants (WDIs; diameter >3.75 mm) has increased, especially in the posterior jaw, because it is generally accepted that WDIs improve the ability of posterior implants to tolerate the occlusal forces, create a wider base for proper prosthesis, and avoid the placement of two standard-size implants (SSIs) (3.75 mm) at one site to obtain a double-root prosthetic tooth.[1-14]

Clinical outcomes of WDIs have been studied in terms of survival rate (SRR; i.e., implants still in place at the end of the follow-up) or, when the SRR was too high to detect any statistical differences among the studied variables, in terms of success rate (SCR) by analyzing variables such as peri-implant bone loss, probing depth, plaque index, and bleeding index.[1-10]

In 1993, a new 5.0-mm wide, self-tapping implant was introduced.[1] The recommended indications for its use included poor bone quality, inadequate bone height, immediate replacement of non-osseointegrated implants, and immediate replacement of fractured implants. The last two indications (or rescue indications) were rejected subsequently after some authors[2-10] provided data regarding implant survival.

Bahat and Handelsman[2] compared WDIs and double-root implants inserted in the posterior jaw. All implants were uncovered and restored with ceramometal crowns. SRR was 97.7% and 98.4% for WDIs and double-root implants, with a mean postloading follow-up of 13 and

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37 months, respectively. Aparicio and Orozco[3] reported a global SRR of ~90% for 94 WDIs, with a mean postloading follow-up of 33 months. Similar results were reported by Renouard et al.,[4] who analyzed 98 WDIs with an SRR of 91.8%; a lower SRR (82%) was detected by Ivanoff et al.,[5] who studied 97 WDIs with a 5-year follow-up. Higher SRRs were obtained by Brånemark et al.,[6] who presented a study on 150 immediately loaded WDIs (SRR = 98%); Khayat et al.,[7] who analyzed 131 WDIs with an SRR of 95% and a mean loading time of 17 months; Friberg et al.,[8] who performed a retrospective study, with a mean follow-up of 2 years and 8 months, of 157 WDIs with a 4.5% failure rate; and Krennmair and Waldenberger,[9] who studied 121 WDIs with a mean follow-up of 42 months and an SRR of 98.3%. In addition, Griffin and Cheung[10] presented a retrospective investigation on the use of short WDIs in posterior areas with reduced bone height; 168 hydroxyapatite (HA)-coated implants were placed. Mean follow-up was 35 months after loading, and SRR was 100%.

Regarding prostheses, Sato et al.[11,12] studied the advantages of using WDIs instead of two or three SSIs in the posterior jaw. The use of a staggered buccal and lingual offset placement of implants is believed to be able to prevent the loosening or fracture of screws that attach the prostheses to the implants. The authors found that the offset placement did not always decrease the tensile force at the gold screw when three SSIs were used, but WDI did.[11] The same authors[12] showed that the biomechanical advantage of double implants for single molar replacement was questionable, compared to WDI, when the occlusal force was loaded at the occlusal surface near the contact point. On the contrary, Moscovitch[13] reported that the use of two SSIs to restore a molar could reduce the problems associated with decreased bone volume and heavy occlusal loads with or without parafunctional habits. Finally, Huang et al.[14] studied the effect of splinted prosthesis in the molar region; they concluded that the biomechanical advantages of using the WDI or two SSIs were almost identical. The benefit of load sharing by the splinted crowns is notable only when the implants in the premolar and molar regions have different supporting abilities.

Although good clinical outcomes were reported in the above-mentioned studies, especially in recent years, there are no large series, and only one report focused on the effect of immediate loading (IL) on WDIs.[6] IL is an emerging technique in implantology because it is a successful and time-saving procedure.[15-18] Thus, we planned a retrospective study on 304 WDIs to evaluate the clinical outcome with special attention to IL.

MATERIALS AND METHODS

Patients

From October of 1996 to December of 2004, 205 patients (103 males and 102 females; median age, 49 years; range, 18 to 87 years) were operated on. Informed written consent to use data for research purposes was approved by the Ethics Committee of the University of Chieti-Pescara and obtained from each patient. The last control was performed in July of 2005, with a mean postloading follow-up of 30 months (range, 8 to 106 months).

Subjects were screened according to the following inclusion criteria: controlled oral hygiene, the absence of any lesions in the oral cavity, and sufficient residual bone volume to receive implants of ≥5.0 mm in diameter and 8.0 mm in length. In addition, patients had to agree to participate in a postoperative control program.

Exclusion criteria were as follows: insufficient bone volume; high degree of bruxism; smoking more than 20 cigarettes per day; excessive consumption of alcohol; localized radiation therapy of the oral cavity; antitumor chemotherapy; liver, blood, and kidney diseases; immunosuppression; current corticosteroid use; pregnancy; inflammatory and autoimmune diseases of the oral cavity; and poor oral hygiene.

Data Collection

Before surgery, radiographs included periapical radiography, orthopantomography, and computerized tomography scanning. Periapical radiographs were used in the follow-up period. For each patient, the peri-implant crestal bone level was evaluated by calibrated examination of periapical x-rays. Measures were recorded after surgery and usually after 12 months and, in all cases, at the end of the follow-up period. The measurements were carried out mesially and distally to each implant, calculating the distance between the edge of the implant and the most coronal point of contact between the bone and the implant. The bone level recorded just after the surgical insertion of the implant was the reference point for the following measurements. The measurement was rounded to the nearest 0.1 mm. A peak scale loupe with a seven-fold magnifying factor and a scale graduated in 0.1 mm was used. Peri-implant probing was not performed because controversy exists regarding the correlation between probing depth and implant success rates.[19,20] Implant SCRs were evaluated according to the following criteria: absence of persisting pain or dysesthesia; absence of peri-implant infection with suppuration; absence of mobility; and absence of persisting peri-implant bone resorption >1.5 mm during the first year and 0.2 mm per year during the following years.[21]

Implants

A total of 304 implants were inserted in 205 patients; all implants had a diameter ≥5.0 mm (WDI). Four Ankylos,§ one Brånemark,‖ 99 Frialit,¶ 41 Maestro,# and 159 XiVE** implants were used. Implant diameters ranged from 5.0 to 6.5 mm, and implant lengths ranged from 8.0 to 15 mm. Implants were inserted as follows: 37 incisors, 40 cuspids, 81 premolars, and 146 molars. A total of 150 implants were placed after extraction, and 154 implants were loaded immediately. Bone qualities were density 1 (D1), D2, D3, and D4 in 15, 152, 115, and 22 cases, respectively.

Surgical and Prosthetic Technique

All patients underwent the same surgical protocol, as described previously.[15-18] Antimicrobial prophylaxis was obtained with amoxicillin, 500 mg, twice daily, for 5 days beginning 1 hour before surgery. Articaine/epinephrine was used for local anesthesia; post-surgical analgesia consisted of nimesulid, 100 mg, twice daily, for 3 days. With IL, patients ate a soft diet for 4 weeks. Oral hygiene instructions were provided.

After a crestal incision, a mucoperiosteal flap was elevated. Implants were inserted according to the procedures recommended. The implant platform was positioned slightly above the alveolar crest. In case of IL, a temporary restoration was relined with acrylic and trimmed, polished, and cemented or screw retained 1 to 2 hours later. Occlusal contact was avoided in centric and lateral excursions. After provisional crown placement, a periapical radiograph was impressed by means of a customized holder device.†† This device was necessary to maintain the x-ray cone perpendicular to the film placed parallel to the long axis of the implant. Sutures were removed 14 days after surgery. Twenty-four weeks after implant insertion, the provisional crown was removed, and a final impression of the abutment was taken using a polyvinylsiloxane impression material. The final restoration was always cemented and delivered ~32 weeks after implant insertion. All patients were included in a strict hygiene recall.

Statistical Analysis

Because only five of 304 implants were lost (SRR = 98.4%) and no statistical differences were detected among the studied variables, no or reduced crestal bone resorption was considered an indicator of SCR to evaluate the effects of several host-, surgery-, and implant-related factors.

The differences between the implant abutment junction and the bone crestal level was defined as the insertion abutment junction (IAJ) and was calculated at the time of operation and during follow-up. ΔIAJ is the difference between IAJ at the last control and IAJ recorded just after the operation. ΔIAJ medians were stratified according to the variables of interest. A general linear model was performed to detect those variables associated with ΔIAJ. Finally, adjusted ΔIAJ values were plotted against months.[22]

RESULTS

Tables 1 through 7 report the median ΔIAJ associated with the studied variables. Five implants were lost in the postoperative period (within 3 months); Table 8 describes their characteristics.

Table 9 shows that distal teeth (i.e., premolars and molars versus incisors and cuspids; Table 2), narrow implants (i.e., 5.0 and 5.5 mm versus 6.5 mm; Table 3), and shorter implants (i.e., length <13 mm versus ≥13 mm; Table 4) correlated with a statistically significant lower ΔIAJ (i.e., reduced crestal bone loss) and, thus, a better clinical outcome.

DISCUSSION

The identification of guidelines for the long-term SRR and SCR (i.e., good clinical, radiological, and esthetic outcomes) are the main goals of the recent literature. Several variables can influence the final result; generally, they are grouped as surgery-, host-, implant-, and occlusion-related factors.[23] Surgery-related factors include several variables, such as an excess of surgical trauma (e.g., thermal injury),[24] bone preparation,[25] and drill sharpness and design.[26] Bone quality and quantity are the most important host-related factors,[27-31] whereas design,[32-34] surface coating,[28,32,35] diameter,[1-14] and length[31] are the most important implant-related factors. Among the occlusion-related factors, quality and quantity of force[36,37] and prosthetic design[38-40] are the variables of interest. All of these variables are subjects of scientific investigations because they may affect the clinical outcome.

In addition, each variable has specific indications. For WDI, e.g., it depends on the edentulousness, the volume of the residual bone, the amount of space available for the prosthetic reconstruction, the emergence profile, and the type of occlusion. WDIs are indicated, especially in the posterior jaw, because it is generally accepted that WDIs improve the ability of posterior implants to tolerate the occlusal forces, create a wider base for proper prosthesis, and avoid the placement of two SSIs (3.75 mm) at one site to hold a double-root prosthetic tooth. WDIs provide a greater interface with supporting bone that is stronger than with SSIs and reduce the risk for screw fracture. When

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Table 1.

Distribution of Series With Regard to Implant Type and ΔIAJ

Implant	N (median)
Ankylos	4 (0.35)
Brånemark	1 (1.2)
Frialit	99 (1.4)
Maestro	41 (1.0)
XiVE	159 (0.65)

Table 2.

Distribution of Series With Regard to Tooth Site and ΔIAJ

Site	N (median)
Incisors	37 (1.1)
Cuspids	40 (1.1)
Premolars	81 (0.9)
Molars	146 (0.7)

Table 3.

Distribution of Series With Regard to Implant Diameter and ΔIAJ

Diameter (mm)	N (median)
5.0	42 (1.0)
5.5	248 (0.8)
6.5	14 (1.8)

Table 4.

Distribution of Series With Regard to Implant Length and ΔIAJ

Group	N (median)
I (length <13 mm)	162 (0.7)
II (length ≥13 mm)	142 (1.0)

Table 5.

Distribution of Series With Regard to Postextraction Implant Insertion (group II) and ΔIAJ

Group	N (median)
I	154 (0.8)
II	150 (0.9)

Table 6.

Distribution of Series With Regard to Bone Quality and ΔIAJ

Bone Quality	N (median)
D1	15 (1.6)
D2	152 (0.8)
D3	115 (0.9)
D4	22 (0.65)

Table 7.

Distribution of Series With Regard to Type of Loading and ΔIAJ

Group	N (median)
I (control)	150 (1.0)
II (IL)	154 (0.7)

prosthetic components match the increased diameter of the implant, they also may lead to better esthetics, optimal emergence profiles, and improved oral hygiene. Initially used as rescue implants,[1] WDIs have become the first choice in clinical situations such as tooth extraction, poor bone quality, limited crestal height, bruxism, and cantilevers.[2-10]

Several medium-term studies of WDIs demonstrated favorable survival rates (>97%) with two-stage procedures.[2,7-10] However, several investigators[3-5] reported less successful results. Aparicio and Orozco[3] reported a global SRR of ~90% for 94 WDIs, with a mean postloading follow-up of 33 months. Similar results were reported by Renouard et al.,[4] who analyzed 98 WDIs with an SRR of 91.8%; lower values were reported by Ivanoff et al.,[5] who studied 97 WDIs with a 5-year follow-up and an SRR of 82%. Brånemark et al.[6] presented 150 IL WDIs with an SRR of 98%.

Table 8.

Description of Implants That Failed Within 3 Months After Operation

Type	Site	Diameter (mm)	Length (mm)	Postextractive	Type of Loading	Bone Quality
XiVE	Incisor	5.5	15	Yes	Immediate	D2
XiVE	Premolar	5.5	9.5	No	Delayed	D2
Frialit	Incisor	6.5	15	Yes	Immediate	D2
Frialit	Incisor	6.5	15	Yes	Immediate	D2
Maestro	Incisor	5.0	12	Yes	Immediate	D3

Table 9.

Output of the General Linear Model Reporting the Variables Associated Statistically With ΔIAJ

					95% Confidence Interval	
Parameter	β	SE	*t*	Significance	Lower Boundary	Upper Boundary
Intercept	–1.949	0.327	–5.960	0.001	–2.593	–1.306
Tooth site	–7.175 E-02	0.019	–3.853	0.001	–0.108	–3.510 E-02
Diameter	0.416	0.060	6.960	0.001	0.299	0.534
Length	0.170	0.039	4.327	0.001	9.245 E-02	0.247
Months	1.087 E-02	0.001	17.321	0.001	9.636 E-03	1.211 E-02

In this article, we have reported a larger series of 304 cases, with only five implants lost during a mean postloading follow-up of 30 months (SRR = 98.4%).

Because no statistical differences were detected among the studied variables by using SRR, no or reduced crestal bone resorption was considered an indicator of SCR to evaluate the effects of host-, surgery-, and implant-related factors.

In general, length (Table 4), type (Table 1), and diameter (Table 3) are considered to be relevant implant-related factors. Tarnow et al.[41] proposed using implants longer than 10 mm for IL. In our series, implant length, diameter, and type were not critical for SRR. Among our implant failures, one was 9.5 mm long, one was 12 mm long, and three were 15 mm long (mean, 13.3 mm). One failed implant was 5.0 mm wide, two were 5.5 mm wide, and two were 6.5 mm wide (mean, 5.8 mm; Table 8). We found a different SCR according to length and diameter (Table 9), with a better outcome with regard to reduced crestal bone loss over time for shorter (<13 mm) and narrower (5.0 and 5.5 mm) implants. In general, the fact that short WDIs have a good outcome is not surprising because Griffin and Cheung[10] reported an SRR of 100%; however, in this study, half of the cases were loaded immediately. Also, Brånemark et al.[6] had a very high SRR (98%) in a series of 150 WDIs that were loaded immediately.

Immediate loading of implants in postextraction sites is one of the main topics in implant dentistry; few reports have focused on this surgery-related factor. In the present study, 156 implants were loaded immediately; 57 were inserted in healed bone and 99 were inserted in postextraction sockets. No statistically significant differences were observed. Consequently, the immediate loading of implants inserted in postextraction sites could be considered a predictable clinical procedure as it is for SSI.[18]

Bone quality, a host-related factor, is believed to be the strongest predictor of outcome in IL. Misch[42] reported that most immediately loaded implants are placed in anatomical sites with bone qualities of D1 or D2. It is well known that the mandible (especially the interforaminal region) has a better bone quality than the maxilla; this probably accounts for why several reports[43-45] of high SRR are available regarding immediately loaded implants inserted in the mandible. We did not find a statistically significant difference

associated with bone quality (Table 6), but there is a worse outcome when WDIs replace incisors or cuspids (Table 2). The narrow alveolar crest of the anterior jaw probably is a limiting factor when using WDIs in these sites. Moreover, the difficulties associated with using WDIs in knife-edge posterior ridges must be borne in mind.

The fact that WDIs can tolerate occlusal forces better than standard-diameter implants was reported recently in finite element analysis and clinical studies.[46-50]

CONCLUSIONS

WDIs are reliable devices, with high SRRs and SCRs, that result in stable situations over time. No differences were detected among implant types. Length and diameter can influence the crestal bone resorption, with better results for narrow and shorter fixtures. Immediate loading is possible in postextraction sockets, and the results are comparable to those seen with SSIs. Bone quality is not a major limiting variable, but WDIs should not be used to replace incisors or cuspids.

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