EFFECT OF NARROW DIAMETER IMPLANTS ON CLINICAL OUTCOME

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Narrow diameter implants (NDI) (i.e. diameter 3.75 mm) are a potential solution for specific clinical situations such as reduced interradicular bone, thin alveolar crest and replacement of teeth with small cervical diameter. NDI have been available in clinical practice since the nineties but only a few studies have analyzed their clinical outcome. Since no report is available on a new type of implants, a retrospective study was performed. A total of 47 narrow diameter (i.e. $x \leq 3.40$ mm) two-piece implants (FMD srl, Rome, Italy) were inserted, 35 in females and 12 in males. The median age was 60 ± 11 (min-max 30-80 years). Implants were inserted 22 in the maxilla and 25 in the mandible; they replaced 11 incisors, 3 cuspids, 21 premolars and 12 molars. Implant' length was shorter than 10 mm, $10.30 \leq x \leq 12.30$, equal to 13 mm and longer than 13 mm in 17, 28, 1 and 1 fixtures, respectively. Implant' diameter was narrower than 3.5 mm. There were 3, 18 and 26 Elisir, I-fix and Shiner implant types. No implant on single tooth rehabilitations was lost and thus survival rate was 100%. Then peri-implant bone resorption (i.e. delta IAJ) was used to investigate SCR. Seven fixtures have a crestal bone resorption greater than 1.5 mm (SCR = 85.1). Statistical analysis demonstrated that diabetes (p=0.044) and smoke (p=0.001) have a higher peri-implant crestal bone resorption. In conclusion FMD implants are reliable devices for oral rehabilitation with a very high SCR and SVR although smoker and diabetic patients have a worse clinical outcome.

The choice of implant diameter depends on the type of edentulism, the volume of the residual bone, the amount of space available for the prosthetic reconstruction, the emergence profile, and the type of occlusion. Particularly, the quantity of bone in the vertical direction and the distance between the teeth adjacent to a missing tooth are the main criteria when selecting the length and diameter of an implant.

Considering that minimal diameter of traditional cylindrical implants is 3.25 mm, sometimes it may not be possible to place even cylindrical implants with smallest diameter (1). If no treatment is applied to the space created after extraction of a natural tooth, the space narrows in the mesio-distal direction because of movement of neighboring natural teeth toward this space.

It is reported that the distance between an implant and a natural tooth must be not less than 1.2 5 mm-0.25 mm (2, 3) of this distance must be reserved for periodontal membrane and the other 1 mm must be reserved for the bone. Leaving a sufficient distance for bone and periodontal membrane for implants placed between natural teeth is important for a proper blood supply necessary for osteointegration. For example, in the case of single tooth deficiency, a 0.25 mm distance must be left on both sides, mesial and distal and 1 mm for the bone, for a cylindrical implant with a smallest diameter of 3.25 mm. For this reason, a total of 5.75 mm is required between 2 teeth (3).

It is not possible to apply conventional implants at spaces narrower than that specified above. Regaining the lost space may only be possible by long-duration and high-cost orthodontic treatment. Some patients do not want to have their teeth prepared for a fixed partial denture. In fact, patients so wishing constitute those who remain edentulous for a long time, which causes narrowing of the space. In such patients, implants with a diameter smaller

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than that of traditional implants are required. (1)

Narrow diameter implants (NDIs) are indicated in specific clinical situations, for example, where there is a reduced interadicular bone or a thin alveolar crest, and for the replacement of teeth with a small cervical diameter (4, 5). Some studies evaluating the clinical outcome of NDIs (<3.5 mm in diameter) placed in different indications, are available. NDI supporting single tooth replacements have shown favorable clinical result in the long-term perspective (6-8). Moreover, studies evaluating fixed partial dentures supported by NDIs have shown good clinical results, both after short and long-term follow-up periods. NDIs have also been used to support full arch reconstructions, and satisfactory results have been shown both for full arch fixed bridges and for overdentures in the mandible and in the maxilla (8-10).

However, no difference in the long clinical outcome between standard diameter implants and NDIs has been observed. In an extensive review was reported that no relationship there is between marginal bone loss and implant diameter.

The NDIs have been developed to allow for implant placement in these situations where there is not enough space for a regular diameter implant. Thus, the need for bone augmentation or orthodontic tooth movement can be avoided.

Here we analyses a large series of two-pieces implants (FMD srl, Rome, Italy) in order to evaluate their survival (i.e. total number of fixtures still in place at the end of the follow-up) and success rate (i.e. peri-implant bone resorption).

MATERIALS AND METHODS

A) Study design/sample

To address the research purpose, the investigators designed a retrospective cohort study. The study population was composed of patients admitted at the private practice for evaluation and implant treatment by M.A.L. and M.A.B. between January 1996 and October 2011.

Subjects were screened according to the following inclusion criteria: controlled oral hygiene and absence of any lesions in the oral cavity; in addition, the patients had to agree to participate in a post-operative check-up program.

The exclusion criteria were as follows: bruxists, consumption of alcohol higher than 2 glasses of wine per day, localized radiation therapy of the oral cavity, antitumor chemotherapy, liver, blood and kidney diseases, immunosupressed patients, patients taking corticosteroids, pregnant women, inflammatory and autoimmune diseases of the oral cavity.

B) Variables

Several variables are investigated: demographic (age and gender), anatomic (tooth site, jaws), implant (length, diameter and type), related pathologies (diabetes, smoke, periodontal disease, edentulness), surgical (surgeon, post-extraction, guided bone regeneration - GBR), and prosthetic (immediate loading, number of crowns) variables.

The predictors of outcome are the percentage of implants still in place at the end of the follow-up period (i.e. survival rate – SVR) and the peri-implant bone resorption. The latter is defined as implant success rate (SCR) and it is evaluated according to the absence of persisting peri-implant bone resorption greater than 1.5 mm during the first year of loading and 0.2 mm/years during the following years (11).

C) Data collection methods

Before surgery, radiographic examinations were done with the use of intra-oral radiographs and orthopantomographs.

Peri-implant crestal bone levels were evaluated by the calibrated examination of intra-oral radiographs and orthopantomograph x-rays after surgery and at the end of the follow-up period. The measurements were carried out medially and distally to each implant, calculating the distance between the implant's neck 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 off to the nearest 0.1 mm. The radiographs were performed with a computer system (Gendex, KaVo ITALIA srl, Genova, Italia) and saved in uncompressed TIFF format for classification. Each file was processed with the Windows XP Professional operating system using Photoshop 7.0 (Adobe, San Jose, CA), and shown on a 17" SXGA TFT LCD display with a NVIDIA GÈ Force FX GO 5600, 64 MB video card (Acer Aspire 1703 SM-2.6). By knowing dimensions of the implant, it was possible to establish the distance from the medial and distal edges of the implant platform to the point of bone-implant contact (expressed in tenths of a millimeter) by doing a proportion.

The difference between the implant-abutment junction and the bone crestal level was defined as the Implant Abutment Junction (IAJ) and calculated at the time of operation and at the end of the follow-up. The delta IAJ is the difference between the IAJ at the last check-up and the IAJ recorded just after the operation. Delta IAJ medians were stratified according to the variables of interest.

D) Surgical protocol

All patients underwent the same surgical protocol. An antimicrobial prophylaxis was administered with 1g Amoxycillin 875 mg + Clavulanic acid 125 mg twice daily for 5 days starting 1 hour before surgery. Local anesthesia was induced by infiltration with articaine/epinephrine and post-surgical analgesic treatment was performed with 600 mg Ibuprofen twice daily for 3 days. Oral hygiene instructions were provided.

Two-piece implants (FMD srl, Rome, Italy) were inserted with a flap elevation approach. The implant neck was positioned at the alveolar crest level. Guided bone regeneration could be performed in the same surgical step. A second operation was then performed after four months to loading by means a provisional prosthesis. The final restoration was usually delivered within 8 weeks. All patients were included in a strict hygiene recall.

E) Data analysis

Pearson-chi square test was used to detect those variables statistically associated to SVR and SCR.

RESULTS

A total of 47 narrow diameter (i.e. x ≤ 3.40 mm) two-piece implants (FMD srl, Rome, Italy) were inserted, 35 in females and 12 in males. The median age was 60 ± 11 (min-max 30-80 years). Implants were inserted 22 in the maxilla and 25 in the mandible; they replaced 11 incisors, 3 cuspids, 21 premolars and 12 molars. Implant' length was shorter than 10 mm, 10.30 ≤ x ≤ 12.30, equal to 13 mm and longer than 13 mm in 17, 28, 1 and 1 fixtures, respectively. Implant' diameter was narrower than 3.5 mm. There were 3, 18 and 26 Elisir, I-fix and Shiner implant types. All the implant bodies received the same surface treatments (i.e. sand blasting and acid etching) while the neck was leftsmooth in Elisir, Shiner, storm types. I-fix received the same surface treatment involving the neck too.

Eight diabetic patients were enrolled, 31 had periodontal disease and 20 were smokers. Two surgeons performed operation. Fixtures were placed in one totally edentulous patient, 1 single missing tooth and 45 partially edentulous subjects. One implant was placed in post-extraction sockets; GBR was performed onto 6 fixtures and none was immediately loaded. There were 21 single crowns and 25 implants bearing 2 or greater bridges. One carried a removable denture.

The overall mean follow-up was ±63 months.

No implant on single tooth rehabilitations was lost and thus survival rate was 100%.

Then peri-implant bone resorption (i.e. delta IAJ) was used to investigate SCR. Seven fixtures have a crestal bone resorption greater than 1.5 mm (SCR = 85.1).

Statistical analysis demonstrated that diabetes (p=0.044) and smoke (p=0.001), have a higher peri-implant crestal bone resorption.

DISCUSSION

Misch and Judy (12) have classified the jaws and the quantity of the remaining bone when determining different types of implants and the sizes of these implant types. This classification specifies the volume of bone required for different types of implants to provide osteointegration around the implants. (12) It is advocated the existence of 0.5-mm thick bone around the implants both at the vestibular side and at the oral side for long-term success of implants. For this reason, it is reported that bone thickness must be at least 5 mm in the vestibule-lingual direction for cylindrical implants (1).When there is
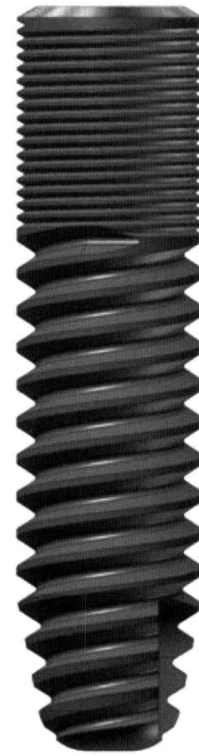

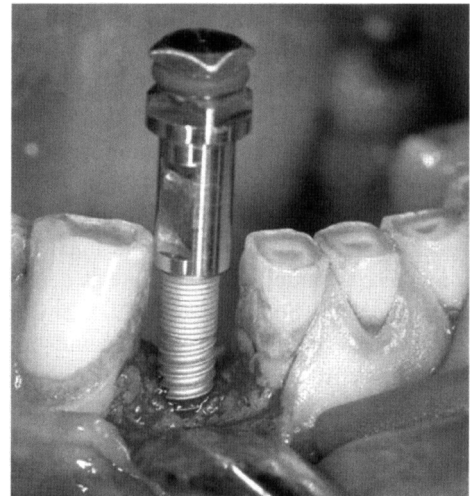**Fig. 1.** *Dental implant*

Fig. 2. *Surgical procedure*

insufficient bone around the implants at the vestibule and lingual sites the volume of the bone can be increased by applying augmentation. However, when there is a narrow space between 2 natural teeth, implants that have smaller diameters should be used.

Vigolo and Givani (1) used mini-dental implants with a diameter of 2.9 mm for treatment of single tooth deficiency at narrowed edentulous spaces and reported

high rates of success. Their diameter of 2.9 mm does not allow use at spaces with a mesiodistal distance less than 5.4 mm. However, the diameter of 2.4 mm of mini-dental implants allows its use also at the maxilla when there is a space smaller than 5.4 mm between 2 natural teeth.

In implant dentistry, the use of regular size implant is generally recommended to ensure adequate bone to implant contact. Occasionally, the available space may be insufficient for the placement of regular size implant and, in these cases; NDI can be an acceptable solution. NDIs are used in areas where ridge dimension is narrow or space is limited. These conditions are frequently found in the maxilla, especially in situations where teeth are congenitally missing. Lack of sufficient space for a regular size implant is also common in the mandibular incisor, maxillary premolar and canine regions.(1, 10, 13, 14)

Reducing the diameter, on the other hand, was shown to increase the risk of implant fracture due to lower mechanical durability. In the study conducted by Volkan et al. (15) all implants were placed into native bone without the need for further grafting. However, insufficient bone thickness may not be favored, especially in the long term, and thus should be supplemented by possible guided bone regeneration methods. Despite the long service time and posterior placement (elevated stresses), no implant fractures occurred during the 10-year course of this study. This could be related to the use of a sufficient number of implants, careful analysis and design of prosthetic occlusal scheme and splinting of NDIs to other implants when possible. Thus, a long service life may be expected of NDIs, provided that sufficient numbers of NDIs are used to support a well-designed prosthesis.

Moreover, has been clearly shown that both inlay and onlay grafting procedures of atrophic maxillas seem to greatly increase the implant failure rate as compared with standard procedures. So, the use of a NDI in Cawood and Howell class IV maxillary atrophies could be regarded as a very reliable alternative to bone grafting procedures. With regard to the dehiscence present at many implant sites after placement, these were managed with autologous bone chip coverage without affecting the outcome of the treatment after 1 year of loading. This was carried in accordance with clinical recommendation by Lekholm et al.(16) who observed that incomplete bone coverage at implant placement does not influence the 5-year outcome of the implants. Incomplete bone coverage of some threads is therefore an acceptable situation that does not require previous grafting to improve the bone support.

Here we reported that no implant was lost and thus survival rate was 100%. Then peri-implant bone resorption (i.e. delta IAJ) was used to investigate SCR. Seven fixtures have a crestal bone resorption greater than 1.5 mm (SCR = 85.1). Statistical analysis demonstrated

that diabetes (p=0.044) and smoke (p=0.001) have a higher peri-implant crestal bone resorption.

In conclusion FMD implants are reliable devices for oral rehabilitation with a very high SCR and SVR although smoker and diabetic patients have a worse clinical outcome.

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