Clinical evaluation of single-tooth mini-implant restorations: A five-year retrospective study

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Statement of problem. Placement of small diameter implants often provides a solution to space problems in implant restoration. Analysis of the success of this type of implant restoration has not been clearly determined.

Purpose. This 5-year retrospective study presents results from 52 mini-implants for single-tooth restorations placed in 44 patients from 1992 to 1994.

Material and methods. Dental records of 44 patients with 52 mini-implants placed during 1992-94 were reviewed. The implants were all placed by the same surgeon and the single-tooth custom screwed posts with cemented crowns were positioned on the implants by the same prosthodontist.

Results. The results achieved by the mini-implant rehabilitation were similar to those reported for standard single-tooth implant restoration. Total implant survival rate was 94.2%. Two implants were lost at second stage surgery, and another was lost after temporary loading.

Conclusion. The results suggest that single-tooth mini-implant restoration can be a successful treatment alternative to solve both functional and esthetic problems. They may represent the preferred choice in cases where space problems limit the use of standard or wide diameter implants. (J Prosthet Dent 2000; 84:50-4.)

CLINICAL IMPLICATIONS

Single-tooth mini-implant restorations demonstrated a rate of success similar to those reported by previous studies for standard single-tooth implant restoration. Therefore, a mini-implant may represent a valid treatment alternative when space problems occur.

The rate of success of implants in the edentulous mouth has encouraged dentists to extend this application to the replacement of single missing teeth. Highly evolved surgical techniques and the introduction of special components for single-tooth replacements allowed functional and esthetic improvements.[1] The use of standard-sized or of wide-diameter implants is suggested to allow favorable contact surface between the bone and the implant itself.[2] Occasionally, lack of space does not allow the dentist to place implants of such dimensions. An adequate solution in these circumstances, when single-tooth restorations are needed and the space is not sufficient to insert a standard or a wide diameter implant, is the mini-implant.

From the data available in the literature, regular-sized osseointegrated implants showed similar behavior in the rehabilitation of totally and partially edentulous arches and in single-tooth replacement.[1,3-20] With regard to the rehabilitation of totally edentulous arches, Ahlqvist et al[6] studied osseointegrated implants in 50 edentulous jaws during a 2-year observation period. The implant survival rate was 89% in the maxillae and 97% in the mandibles. Zarb and Schmitt[7] studied, prospectively, the 5- to 10-year results of treatment of edentulous patients with osseointegrated implant-supported bridges. At the end of the 5- to 10-year observation period, 88.32% of the implants remained osseointegrated and 85.04% of these implants were used to support 43 fixed prostheses and 5 overdentures.

For rehabilitation of partially edentulous arches, Van Steenberghe[10] evaluated the prognosis of the osseointegration technique applied for the rehabilitation of partially edentulous jaws a multicenter retrospective study. The observation time varied between 6 and 36 months after prosthetic reconstruction. The success rate for the individual implants in the maxilla and mandible was 87% and 92%, respectively. Zarb and Schmitt[11] studied prospectively the results of osseointegrated implants placed in partially edentulous areas in the posterior zones. One hundred five implants were placed in 46 edentulous areas in 35 patients. After periods of loaded service ranging from 2.6 to 7.4 years (mean 5.2 years), of the 41 implants placed in maxillae, 40 (97.6%) remained in function, and of the 64 placed in mandibles, 59 (92.2%) remained in function, with an overall implant survival rate of 94.3%. Zarb and Schmitt[12] also reported an average success rate of 91.5% for implants placed in the anterior part

[a]Private Practice.

of partially edentulous mouths both in the maxilla and in the mandible.

With regard to single-tooth restorations, Cordioli et al[1] reported the clinical experience of 47 patients treated for a single-tooth replacement exhibiting a total implant survival rate of 94.4%. Engquist et al[18] evaluated the outcome of single-tooth restorations on Brånemark implants performed during the period 1984-1989, showing an overall survival rate of 97.6%. McMillan et al[20] investigated the nature, timing, and frequency of complications associated with single-tooth implant therapy in a dental hospital and 2 dental offices and they determined an implant survival rate of 96%.

The literature provides laboratory studies that show the different results when using different diameter implants. Ivanoff et al[21] studied the influence of diameter on the integration of titanium screw-shaped implants in rabbit tibia by means of removal torque measurements and histomorphometry. They inserted implants 3.0, 3.75, 5.0, and 6.0 mm in diameter and 6.0 mm long through one cortical layer in the tibial methaphyses of 9 rabbits and allowed them to heal for 12 weeks. The implants were then unscrewed with a torque gauge and the peak torque required to shear off the implants was recorded. The biomechanical tests showed a statistically significant increase of removal torque with increasing implant diameter. Two distinct studies have questioned the importance of implant diameter: In the first study,[22] the effect of diameter and length on the pullout force required to extract hydroxylapatite-coated implants from dog alveolar bone was compared. After 15 weeks of integration, implants of 3.0, 3.3, and 4.0 mm diameter and 4, 8, and 15 mm length were pulled. The results of this study showed that the ultimate pullout force correlated strongly to implant length, but not to diameter. The second study[23] compared the pullout resistance of small and large diameter (3.25 and 4.25 mm) dental implants placed in the mandibles of 5 embalmed humans and the relationship of these implants to bone density. The maximum pullout force required for the large diameter implants was 15% greater than that required for the small diameter implants, but the difference was not significant. In the same study, a significant positive correlation between the pull-out resistance and the bone density for both the large and small diameter implants ($P<.05$ and $P<.01$, respectively) was noted. However, the real clinical significance of torque and pullout tests is controversial.

The aim of this retrospective study was to collect and summarize 5 years of clinical data on a group of patients treated with the use of 2.9-mm mini-implants (3i Implant Innovations, Inc, Palm Beach Gardens, Fla.) for single-tooth restorations in a private clinic environment.

Fig. 1. Patient missing maxillary lateral incisor because of agenesia. Canine in lateral position has been modified slightly to assume morphology at lateral incisor position. Mini-implant inserted in canine area.

MATERIAL AND METHODS

Between 1992 and 1994, 197 patients were offered implant treatment in a private practice; a total of 638 implants were inserted. A sample group of 44 patients (26 women and 18 men) was investigated; 8 patients exhibited dental agenesia, 17 had lost teeth from dental trauma, and 19 missed teeth as a result of caries or periodontal disease. During the inclusion period, these 44 patients were provided with mini-implants supporting single restorations to replace the missing teeth. The ages ranged from 18 to 74 years (mean age of 35). All patients were in good health. All patients in the sample group returned for recall and all 44 are included in the initial and final data.

A total of 52 2.9 mm mini-implants (3i Implant Innovation, Inc) were positioned after a 2-stage surgical technique (Fig. 1). The 2.9-mm implants were chosen because no space was available for wider implants. Because of space problems the surgeries had to be carefully accomplished with the guidance of a template to decrease the risk of damaging the adjacent teeth and to reduce the difficulties in the prosthetic phase due to poor positioning of the implant. If an implant had to be placed in an extraction site, a 2-month waiting period allowed esthetic healing of the soft tissues before implant placement. Five implants were inserted at the extraction time of traumatized maxillary lateral incisors so as to accelerate the treatment. The total number and type of teeth replaced by implants, the length of the implants used, and the quality of the bone[24] in the implant sites are presented in Tables I through III.

At second stage surgery, the titanium healing cap connection was made. The final restorations were fabricated after conventional procedures for cemented

Table I. Site, cause of tooth loss, and number of single teeth replaced using mini-implants

Site	Cause of tooth loss	Number of single teeth replaced
Maxilla		
Central incisor	Trauma	1
Lateral incisor	Trauma, agenesia	14
Canine	Agenesia	2
First premolar	Caries, periodontal disease	8
Second premolar	Caries, periodontal disease	4
Total		**29**
Mandible		
Central incisor	Trauma	5
Lateral incisor	Trauma, periodontal disease	5
Canine	Trauma	3
First premolar	Trauma, periodontal disease, caries	5
Second premolar	Trauma, periodontal disease, caries	4
First molar	Caries	1
Total		**23**

Table II. Length of mini-implants used for single-tooth replacement (3i Implant Innovations)

Length (mm)	Number of implants
8.5 (MI 085)	1
10 (MI 100)	20
13 (MI 130)	22
15 (MI 150)	9

Table III. Bone quality at the implant sites[24]

Bone quality	Number of implants
Type I	12
Type II	22
Type III	14
Type IV	4

single-tooth restoration with a screw-retained abutment and a cemented crown technique.

Gold-machined UCLA abutments (GUCA3, 3i Implant Innovations, Inc) were used. The gold UCLA-type abutments were screwed on top of the implant replicas using waxing posts and wax added directly to the gold cylinders according to standard waxing procedures. The waxed-up cylinders were then invested in a carbon-free phosphate-bonded investment (Ceramicor, Cendres & Métaux SA, Biel-Bienne, France) and cast with a noble alloy (Al Med, Cendres & Métaux SA). A custom-screwed post was fabricated for all the mini-implants (Fig. 2); the custom posts were screwed on top of the implants in the patients' mouths by using a torque wrench calibrated at 30 N·cm (torque driver CATDO, 3i Implant Innovations, Inc) and a provisional resin crown was temporarily cemented on each post

Fig. 2. Custom-screwed post on top of mini-implant at time of final impression.

and left in the mouth for a 2-month period (temporary cement: Temp Bond NE, Kerr Italia Sp A, Scafati, Salerno, Italy). This temporary phase allowed good definition and stability of the peri-implant soft tissues. This also permitted evaluation of the occlusal scheme and to perform the appropriate variations to the occlusal contacts both static and dynamic. In 7 patients where the esthetic aspects were particularly important, mucogingival surgeries were accomplished to improve the appearance of the gingiva. After this initial temporary phase, the custom posts were reprepared in the patients' mouths to follow the matured gingival morphology; then they were unscrewed, polished by the laboratory technician and repositioned on the implants. Final impressions of the mini-implant posts were accomplished following conventional crown and bridge techniques by using custom trays and polyether material: Impregum F (ESPE Dental-Medizin GmbH & Co KG) was used in the trays and Permadyne L (ESPE Dental-Medizin GmbH & Co KG) in the syringes. Gingival retraction was accomplished with a nonimpregnated retraction cord (Z-Twist Gingi-Plain, Gingi-Pak, Belport Co, Inc, Camarillo, Calif.). For 36 implants, regular porcelain-fused-to-metal final crowns with porcelain occlusal were made (Fig. 3); for the remaining implants, where the esthetic factors were of minor importance, 16 resin gold crowns with gold occlusal were constructed. The occlusal surfaces of the crowns were designed to avoid premature contact during lateral and protrusive movements.

All final crowns were cemented with temporary cement (Temp Bond NE, Kerr Italia Sp A). After prosthetic treatment, a follow-up program was designed for all patients; this provided the opportunity to check the patients every 3 months in the first year and every 6 months in the following years. All the patients regularly returned to the office for recall. Five years after the implant insertion, at the last follow-up appoint-

Fig. 3. Porcelain-fused-to-metal crown cemented on custom-screwed post 5 years after mini-implant insertion.

ment, all patients were seen and periodontal parameter data were compiled on peri-implant mucosal response (dichotomic records on 4 surfaces): supragingival plaque, gingival inflammation, bleeding on probing, amount of keratinized gingiva around abutment, and probing depth from the gingival margin.

All cemented crowns were carefully removed with the GC removal pliers (K.Y. type, GC Corporation, Tokyo, Japan) to avoid damaging the crowns. The custom posts were unscrewed to allow the measurement of the mucosal canal using a periodontal probe to record the length from the marginal gingiva to the head of the implant. Intraoral radiographic examinations were performed using the paralleling technique and an adjusted film-holding device as suggested by previous studies.[1,25] The radiographic films were observed using a 5× magnifying lens to precisely reveal the implant threads and permit the measurement of marginal bone resorption with an accuracy of ±0.3 mm. Occlusal relationships and all complications were recorded.

RESULTS

During the 5-year period of this study, 2 implants (10 mm in length) failed at the second surgical phase. These units were placed in the first premolar sites in the upper maxilla (bone quality 4) in a 52-year-old woman. Another implant (13 mm length) placed in the lower left lateral incisor site of a 25-year-old woman was lost 1 month after the custom post was positioned on the implant and the temporary crown was cemented.

One patient reported the loosening of the custom-screwed post twice. The post was remade and the problem did not recur. Five patients reported fracture or loosening of the provisional resin crowns. The problem was solved by making an accurate adjustment to the patient's occlusion. Seven patients reported recurrent loosening of provisionally cemented final crowns all with porcelain occlusal surfaces. This problem was solved by selective equilibration to achieve optimal occlusion and to avoid contact in lateral and protrusive movements.

Table IV. Periodontal parameters recorded by dichotomic records (presence or absence)

Periodontal indices records	Percentage
Plaque presence	12
Gingival inflammation	4.5
Bleeding on probing	6.5
Amount of facial keratinized gingiva	91
Amount of lingual keratinized gingiva	94.5

The clinical evaluation of peri-implant mucosa using periodontal indices gave satisfying results for the implant-mucosa interfaces (Table IV). Dental plaque was present on 12% of the considered surfaces and gingival inflammation was present on only 4.5%. Keratinized attached gingiva was not present in 9% of buccal surfaces or in 5.5% of lingual surfaces. A mean probing depth of 2.3 mm was recorded, less than reported in some other studies.[1,26,27] The probing was carefully accomplished and a low percentage of sites (6.5%) had bleeding on probing. The mean marginal bone resorption at the last checkup, measured with the intraoral radiographic examination method previously described from the apical end of the smooth collar of the mini-implant, was 0.8 mm, with a range of 0.5 to 1.1 mm.

DISCUSSION

This 5-year retrospective study presents the results from 52 mini-implants for single-tooth replacement inserted in 44 patients from 1992 to 1994. All implants were put in position by the same surgeon and all custom-screwed posts with single cemented crowns were positioned on implants by the same prosthodontist. In this study, the mini-implants used in single-tooth rehabilitation exhibited a 94.2% success rate similar to the results accomplished by regular-sized implants in single-tooth replacement cases.[1,14-20]

The mini-implant is commonly used in areas of narrow ridge dimension or where prosthetic space is limited.[2] This often occurs in the anterior maxillary region, especially in situations of congenitally missing teeth and after orthodontic treatment, wherein the lack of space does not allow use of a regular-sized implant. A space problem frequently results as well in the mandibular incisors and in the maxillary premolar and canine areas. Furthermore, the presence of thin posterior mandibular ridges that would require bone augmentation surgery before the insertion of standard-sized or wide diameter implants. In such situations, insertion of small diameter implants would enable the

dentist to rehabilitate the patient without preinstallation surgery.

All implants were restored with custom posts and cemented final crowns in anticipation of achieving more natural esthetic results. As previously said, the occlusal scheme had to be carefully equilibrated to avoid prematurities in eccentric movements. All our minor prosthetic problems (fracture of the resin provisional crowns, decementation of provisional resin crowns, decementation of final crowns) were associated with occlusal prematurities. For maxillary canine substitution, we tried to concentrate the lateral guiding movements in the first premolar area. In 1 patient, a 2.9-mm mini-implant was positioned in the first lower right molar site where the thin crestal ridge did not allow the placement of a wider diameter implant. The final restoration in that situation was a regular porcelain-fused-to-metal crown with porcelain occlusal: The crown shape was reduced to the dimension of a mandibular premolar to better control the occlusal contacts of the restoration.

Only 1 patient reported the loosening of the custom-screwed post. After closer analysis, the post showed some casting imperfections at the hexagon level. The post was remade and the problem did not recur. It is probable that the internal hexagon pattern of this type of mini-implant reduces the risk of custom-post unscrewing that has been reported by some authors, with relation to standard-sized implant single-tooth restorations.[16]

CONCLUSIONS

Within the limits of this study, the following conclusions were drawn:

1. A success rate of 94.2% was observed. Failures were related to poor bone quality in the recipient sites and to occlusal problems.

2. The single-tooth mini-implant restoration can be a valid alternative in many clinical situations in which space problems do not permit the use of standard- or wide-diameter implants.

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