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MINI-IMPLANTS VERSUS CONVENTIONAL IMPLANTS SUPPORTING PARTIAL OVER-DENTURES IN THE REHABILITATION OF RECONSTRUCTED MANDIBULAR DEFECTS

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ABSTRACT

Objective: This study was conducted to evaluate the effect of using mini-implants versus conventional implants supporting partial over-dentures in the rehabilitation of reconstructed mandibular defects.

Materials and Methods: Ten patients were selected ranging between 40 and 52 years. All patients had unilateral segmental mandibular resection, reconstructed with a free vascularized osseocutaneous fibulous flap with the lateral incisor as the last standing tooth (Class IV Cantor and Curtis Classification). All patients had a full set of natural teeth on the intact side, an intact opposing arch and were free from any systemic disease which may affect bone quality or post-operative healing. A Cone Beam Computed Tomography (CBCT) was performed with the radiographic template in place to select the most suitable sites for implant placement. Patients were divided randomly into two equal groups, each of five patients. Patients of group I received a skeleton partial over-denture supported by two implants (12 mm in length and 3.7 mm in diameter) with a bar and clip attachment at the reconstructed side. Patients of group II received a skeleton partial over-denture supported by two immediately loaded O-ball mini-implants (2.9 mm in diameter and 13 mm in length) with clip attachments at the reconstructed side. For both groups, the design of the partial over-denture framework included a double Aker's clasp on the first and second premolars and molars of the intact side, a gingivally approaching I-bar clasp on the terminal abutment, a lingual plate major connector and a meshwork saddle at the reconstructed free end side. Evaluation of the supporting structures of the terminal abutment and the implants for both groups was carried out at the time of prosthesis insertion and nine months later. It included patients' satisfaction and radiographic evaluation using direct digital radiography.

Results: Patients of both groups were highly satisfied with their prostheses regarding retention, stability, comfort and improved esthetics. A statistically insignificant increase (P>0.05) was observed in the mean marginal bone height measurements, mesial and distal to the implants and distal to the abutment, from the time of prosthesis insertion up to 9 months later in both groups. Also, a statistically insignificant increase (P>0.05) was observed in the mean percentage changes in bone density measurements, mesial and distal to the implants and distal to the abutment in patients of group I, from the time of prosthesis insertion up to 9 months later, as compared to those of group II.

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Conclusions: Implant-supported partial over-dentures can be considered a satisfactory treatment modality in the rehabilitation of reconstructed mandibular defects, which satisfied both the esthetic and functional requirements. Both the bar-retained or the O-ball retained partial over-dentures improved the retention, stability and function of the prosthesis. Besides, the use of the O-ball mini-implants in these situations can be considered a more simplified technique with highly predictable results, as compared to the use of conventional implants.

KEY WORDS: mini-implants, implant-supported partial over-dentures, bar-retained over-dentures, reconstructed mandibular defects.

INTRODUCTION

It is a challenge for clinicians to restore oral functions in patients with segmental defects of the mandible[1]. The most common indication for oro-mandibular reconstruction remains ablative surgery for advanced neoplastic processes of the oral cavity and oropharynx [2].

Mandibular resection leads to altered mandibular movements, disfigurement, difficulty in swallowing, impaired speech and articulation, and deviation of the mandible towards the resected side. Management of patients who require mandibular resection without bony reconstruction is difficult[3]. The reconstruction of these complex three-dimensional composite bony and soft-tissue defects is paramount for rehabilitation of form and function. Vascularized osseous free tissue transfer is the state-of-the-art for mandibular reconstruction with long-term excellent functional and esthetic outcomes. Oromandibular reconstruction, although a challenge for the head and neck reconstructive surgeon, is now reliable and highly successful with excellent long-term functional and esthetic outcomes[2, 4].

Whenever possible, immediate reconstruction at the time of segmental mandibular resection will provide the best esthetic and functional results. Four donor sites (fibula, iliac crest, radial forearm, and scapula) have become the primary sources of vascularized bone and soft tissue for the reconstruction. The fibula has multiple advantages, including bone length and thickness, donor site location permitting flap harvest simultaneously with tumor resection, and minimal donor site morbidity. However, the use of an alternative donor site is best reserved for cases with large soft tissue and minimal bone requirements[5-10].

The free fibula osteocutaneous flap can be considered the most versatile and reliable option for microsurgical reconstruction of large mandibular defects. In addition, the bone height is suitable for an implant-based prosthetic restoration[11-14]. To avoid postoperative ischaemia of the lower leg, adequate perfusion must be guaranteed before sacrificing the peroneal vessels. This improves the versatility of the flap design and decreases the morbidity at the donor site[14,15].

The majority of patients are able to tolerate a regular diet. Intelligible speech and acceptable appearance are restored, thus providing patient satisfaction[16, 17].

Vascularized bone grafts are also the treatment of choice for mandibular replacements over 9 cm in length. Non-vascularized bone grafts are effective for short bone defects (<5-6 cm), in nonirradiated tissue, and/or in patients determined to be too medically compromised to tolerate the additional operative time required for a free-flap reconstruction[18, 19].

It is a challenge for head and neck reconstructive surgeons if the patient (mostly the manual worker) refuses to use fibular flap to reconstruct an extensive mandible defect or the patients have contraindication to harvest fibular flap[9].

Reconstruction of the bony defect alone does not guarantee an adequate foundation for successful conventional prosthetic rehabilitation[20]. The thin cutaneous tissue, the thickness of subcutaneous tissues, the absence of a pelvilingual and vestibular groove, and the fragility of soft tissues complicate dental prosthetic stabilization. The implant-supported prosthesis gives satisfactory results despite the thickness and mobility of soft tissues, and despite scar contracture and the absence of keratinization. Implant placement must be performed after a prosthetic planning. Using radiosurgical guides, despite their cost and difficult adaptation, would certainly improve the technique greatly[21].

Thus, dental rehabilitation through the use of prostheses and osseointegrated dental implants is an important part of the reconstructive process to optimize esthetics and function[10].

Computer-assisted implant rehabilitation of reconstructed defects can achieve superior results to provide fixed dental prosthesis (FDP). However, patient management for FDP rehabilitation is also dependent on the radiation status, soft-tissue modification, and patient selection[22].

The preservation of condyle during free fibula mandibular reconstruction can improve patients' TMJ function. The location and shape of the fibular condyle were important factors that could influence the outcome of condyle reconstruction[23].

When repairing the mandibular defect with free fibular flap, occlusal guide plate with intermaxillary fixation screw contributes to simplifying the operation, accurate recovery of the appearance and occlusal relation, and improving the oral comfort level postoperatively[24].

OBJECTIVE

This study was conducted to evaluate the effect of using mini-implants versus conventional implants supporting partial over-dentures in the rehabilitation of reconstructed mandibular defects.

MATERIALS AND METHODS

Ten patients were selected referred from the National Cancer Institute (NCI), ranging between 40 and 52 years, with an average age of 44 years. All patients had unilateral segmental mandibular resection, reconstructed with a free vascularized osseocutaneous fibulous flap with the lateral incisor as the last standing tooth (Class IV Cantor and Curtis Classification)[25] (***Fig.1***). All patients had a full set of natural teeth on the intact side, an intact opposing arch and were free from any systemic disease which may affect bone quality or post-operative healing. Patients were included in the study after complete healing of the graft and removal of the reconstruction plate.

Fig. (1) A case with a reconstructed mandibular defect.

Patients' Grouping

Patients were divided randomly into two equal groups, each of five patients. Patients of group I received a skeleton partial over-denture supported by two implants with a bar and clip attachment at the reconstructed side. Patients of group II received a skeleton partial over-denture supported by two immediately loaded O-ball mini-implants* with clip attachments at the reconstructed side.

* 3M ESPE MDI Mini Dental Implants, USA.

Design of the partial over-denture framework

For both groups, the design of the partial over-denture framework included a double Aker's clasp on the first and second premolars and molars of the intact side, a gingivally approaching I-bar clasp on the terminal abutment, a lingual plate major connector and a meshwork saddle at the reconstructed free end side.

Construction of the radiographic template

For all patients, upper and lower alginate impressions were made (after modification of the lower stock tray) and poured into dental stone to obtain the study casts. After mounting the casts, diagnostic set-up and waxing-up was carried out and then duplicated into a radio-opaque radiographic template (by mixing clear acrylic resin polymer powder with amalgam powder in a ratio of 9:1 before being mixed with the monomer and applied to the mould).

A Cone Beam Computed Tomography (CBCT) was performed with the radiographic template in place to select the most suitable sites for implant placement.

Implant installation for group I

In the first surgical phase, two implants (12 mm in length and 3.7 mm in diameter)* were installed in the most suitable sites in the grafted mandibular segment, the cover screws were secured to the implants and the muco-periosteal flap was repositioned and sutured. Then, after healing, partial over-denture construction was carried out.

Partial over-denture construction:

For patients of both groups, after mouth preparation, the final impression was made using medium-body rubber base impression material in a custom tray **. Construction of the metal framework and metal try-in was carried out to ensure proper seating. Then, self-curing acrylic resin was adapted to the meshwork saddle and extended to cover the reconstructed free end side of the cast. An altered cast impression technique was done using medium-body rubber base. Then, on the obtained altered cast, an acrylic trial denture base was constructed and the jaw relation was recorded. After mounting the casts, setting up of artificial teeth and final try-in were made. Construction of the partial over-denture was completed in the usual manner for both groups.

Bar construction for group I

In group I patients, the implants were exposed at the time of the second surgical phase (after four months), the cover screws were removed and replaced by healing abutments of a suitable length. The healing abutments were removed after ten days and two impression copings were secured to the implants. A pick-up impression was made using medium body rubber base. On the obtained model, two castable abutments*** were secured to the implant analogues and an OT bar**** was connected to them. After casting, the implant abutments with the bar were secured to the implants (***Fig. 2***). Sufficient relief was made in the fitting surface of the denture and then, direct pick-up of the OT clip attachment was carried out using self-curing acrylic resin.

Implant installation for group II

For group II patients, the radiographic template was used to mark the sites for implant placement using a sharp probe. A tissue punch was used at the marked sites and then, after osteotomy preparation, two O-ball mini-implants, 2.9 mm in diameter and 13 mm in length, were installed (***Fig. 3***).

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* Dentium, Seoul, Korea.
** Impergum Penta 3MESPE, Germany.
*** Dentium, Seoul, Korea.
**** Rhein 83, Italy.

Fig. (2) The OT bar and the abutments secured to the implants.

Fig. (3) The O ball mini-implants of group II.

Then, sufficient relief was made in the fitting surface of the denture and direct pick-up of the clip attachments was carried out using self-curing acrylic resin (***Fig. 4***).

Fig. (4) The partial over-denture in the patient's mouth.

Evaluation of the terminal abutment and the implants

Evaluation of the supporting structures of the terminal abutment and the implants for both groups was carried out at the time of prosthesis insertion and nine months later.

a) Patient satisfaction:

Patients' satisfaction with their prostheses was evaluated by means of a questionnaire developed in consideration of the most important aspects used to evaluate the prosthesis including function, retention, stability and comfort. Patients were asked to rank each prosthesis from 1-3: not satisfied (1), satisfied (2), highly satisfied (3).

b) Radiographic evaluation:

Marginal bone height measurements and densitometric measurements were carried out for both groups distal to the terminal abutment and mesial and distal to each implant using direct digital radiography* .

Rinn-XCP** periapical film holder, individually constructed radiographic templates and long cone paralleling technique were used for standardization of digital images. A digital X-ray machine*** with a long cone, sixteen inches in length was used. The imaging plate was exposed by the X-ray machine at 70-kilovolts and 10-milliamperes, for 0.06 seconds.

i) Marginal bone height measurements:

The linear measurement system supplied by the special software of the Digora was used to assess

* Digora Computerized System, Helsinki, Finland.
** Rinn manufactures Co. Ligin, III, USA.
***Xgenus Degotzen machine, Italy.

the marginal bone height distal to the terminal abutment and mesial and distal to each implant along the follow-up periods. A line was drawn from the top of the abutment to its apex to calibrate the abutment length in the subsequent radiographs before measurements. Similarly, a line was drawn from the top of the bar (in group I) or the top of the O-ball abutment (in group II) to the apex of the implants for calibration of the implant lengths before measurements. Then, after calibration, two lines were drawn, the first line passing tangential to the top of the abutment and the second line was drawn parallel along the distal aspect of the abutment extending from a fixed point at the tangential line and descending perpendicular toward the highest level of the alveolar bone. For the implants, a line was drawn tangential to the top of the bar (group I) or the top of the O-ball abutment (group II). Then, two perpendicular lines were drawn mesial and distal to each implant extending from a fixed point at the tangential line and descending perpendicular toward the highest level of the alveolar bone. The distances recorded along these perpendicular lines were measured to record the alveolar bone changes; any increase in these distances denoted alveolar bone resorption.

ii) Bone density measurements (densitometric analysis)

Using the Digora software, three successive lines were drawn parallel and distal to the root of the terminal abutment. The first line extended from the cemento-enamel junction to the root apex, the second line was drawn parallel and equal to the first line and 1 mm apart from it, while the third line was drawn parallel and 1 mm apart from the second one. Then, the mean value of the three readings was calculated. Similarly, three lines were drawn mesial and distal to each implant extending from the marginal bone crest to the apex of each implant. Then, the mean value of the three readings was calculated. Then, the percentage increase in the mean bone density measurements was calculated according to the following equation:

The percentage increase =

$$\frac{\text{Density (9 months)} - \text{Density (Insertion)}}{\text{Density (Insertion)}} \times 100$$

Statistical analysis

Data were presented as mean and standard deviation (SD) values. Student's t-test was used to compare between the two groups. Paired t-test was used to study the changes by time in each group. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM, SPSS* Statistics Version 20 for Windows.

RESULTS

i) Patient satisfaction

Patients of both groups were highly satisfied with their prostheses regarding retention, stability, comfort and improved esthetics. Besides, patients of group II were highly satisfied with the very simplified technique of mini-implant installation.

ii) Comparison of the mean marginal bone height measurements for both groups

A statistically insignificant increase (P>0.05) was observed in the mean marginal bone height measurements, mesial and distal to the implants and distal to the abutment, from the time of prosthesis insertion up to 9 months later in both groups (***Tables 1&2, figs. 5&6***).

iii) Comparison of the mean bone density measurements for both groups:

A statistically insignificant increase (P>0.05) was observed in the mean percentage changes in bone density measurements, mesial and distal to the implants and distal to the abutment in patients of group I, from the time of prosthesis insertion up to 9 months later, as compared to those of group II (***Tables 3&4, figs. 7&8***).

* SPSS, Inc., IBM Corporation, NY, USA.

TABLE (1) Comparison between bone height changes around the implants in both groups.

Side	Period	Group I		Group II		Period	Mean difference				*P*-value
							Group I		Group II		
		Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Mesial	At insertion	6.71	0.32	5.57	0.21	Insertion to 9 months	0.018	0.003	0.019	0.006	0.760
	9 months	6.73	0.32	5.59	0.21						
Distal	At insertion	6.73	0.29	5.43	0.08	Insertion to 9 months	0.020	0.001	0.021	0.002	0.347
	9 months	6.75	0.29	5.46	0.08						

:$P \le 0.05$ is considered significant.

TABLE (2) Comparison between bone height changes distal to the abutment in both groups.

Period	Group I		Group II		Period	Mean difference				P-value
						Group I		Group II		
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
At insertion	11.69	0.22	11.85	0.28	Insertion to 9 months	0.01	0.004	0.01	0.005	0.352
9 months	11.70	0.22	11.86	0.28						

: $P \le 0.05$ is considered significant.

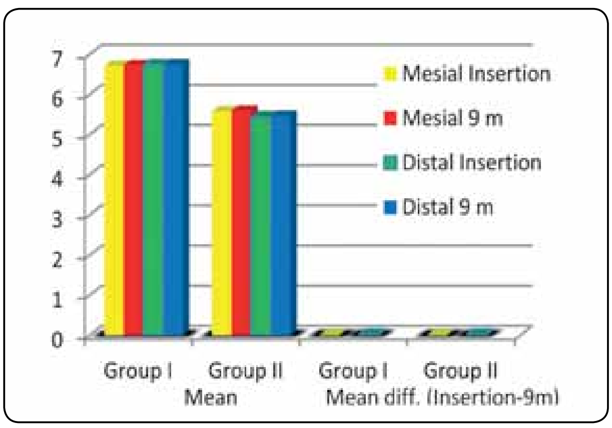

Fig. (5) Comparison between bone height changes around the implants in both groups.

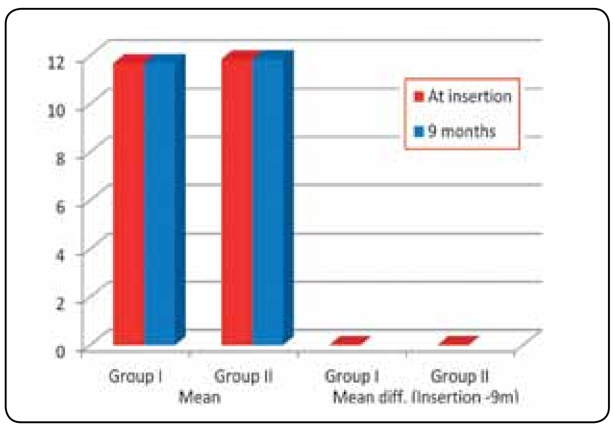

Fig. (6) Comparison between bone height changes distal to the abutment in both groups.

TABLE (3) Comparison between bone density changes around the implants in both groups.

Side	Period	Group I		Group II		Period	% increase				*P* -value
							Group I		Group II		
		Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Mesial	At insertion	172.2	8.8	145.6	4.2	Insertion to 9 months	14.2	2.5	12.6	0.4	0.168
	9 months	196.7	6.2	163.9	4.3						
Distal	At insertion	174	3.1	149.7	1.7	Insertion to 9 months	13.4	0.9	11.6	1.7	0.686
	9 months	197.4	2.9	167	4						

***: P ≤ 0.05 is considered significant.**

TABLE (4) Comparison between bone density changes distal to the abutment in both groups.

Period	Group I		Group II		Period	% increase				P-value
						Group I		Group II		
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
At insertion	168.7	6.4	167.3	5	Insertion to 9 months	11.3	2.4	11.1	0.3	0.312
9 months	187.8	5.5	185.9	5.5						

***: P ≤ 0.05 is considered significant.**

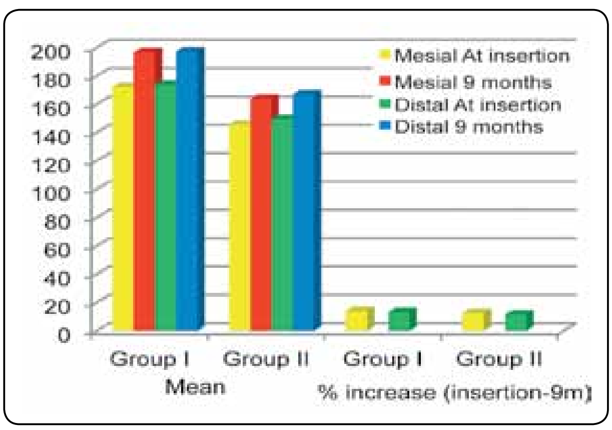

Fig. (7) Comparison between bone density changes around the implants in both groups.

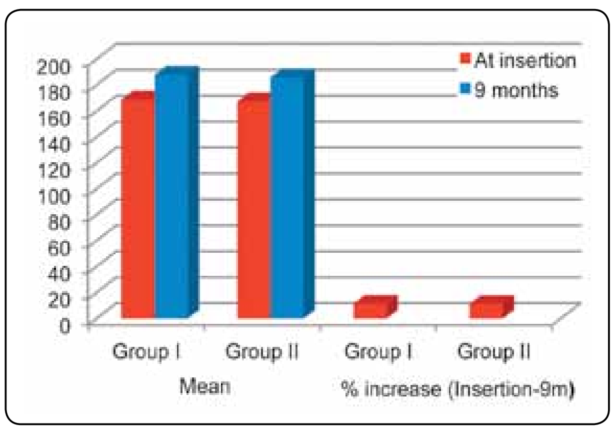

Fig. (8) Comparison between bone density changes distal to the abutment in both groups.

DISCUSSION

Primary and secondary reconstruction of mandibular discontinuity defects with vascularized flap is currently the standard of care in many institutions. Vascularized bone transfers are the ideal bone graft since they provide their own blood supply and all necessary osteoinductive, osteoconductive, and osteoprogenitor elements and thus, they can be used in compromised recipient sites, as indicated by Yaremchuk, 1989[26].

The most commonly used donor site is the fibula, as it provides enough bone length with low donor site morbidity, as well as providing a natural and acceptable jaw appearance. The placement of endosseous implants in the vascularized fibulous flap facilitates functional dental rehabilitation.

Although, removable prostheses are based on the amount of support for the restoration and the hygiene control may be easier, it was reported that the thin cutaneous tissue, the thickness of subcutaneous tissues, the absence of a pelvilingual and vestibular groove, and the fragility of soft tissues complicate removable prosthetic stabilization, as indicated by Bodard et al., 2011[21].

Psychological and anatomic needs and desires can be considered the most important factors in determining the type of implant-supported prosthetic rehabilitation, whether fixed or removable. However, from a functional point of view, with the use of fixed implant-supported restorations, the implants need to support long crowns to reach the occlusal plane with the risk of unfavourable bending movements and implant failure later on, as indicated by Kürkcü et al., 2008[27].

Therefore, the use of implant-supported partial over-dentures can be considered a satisfactory treatment modality for the rehabilitation of reconstructed mandibular defects, which satisfied the esthetic, functional and hygienic requirements of the prosthesis.

The results of the present study revealed that the implants of both groups reacted favourably with the applied occlusal stresses, as indicated by the increase in bone density measurements. Also, the natural abutments in both groups reacted similarly due to the presence of a distal implant support, minimizing the stresses transmitted to the abutments in both groups.

It is worth to mention that the percentage increase in the mean bone density measurements around the conventional implants of group I were slightly insignificantly higher than those of the mini-implants of group II due to the effect of bar splinting. However, the patients of the second group were highly satisfied with the very simplified technique for mini-implant installation with minimum post-operative complications compared to the first group.

CONCLUSIONS

From the results of the present study, it can be concluded that:

1. Implant-supported partial over-dentures can be considered a satisfactory treatment modality in the rehabilitation of reconstructed mandibular defects, which satisfied both the esthetic and functional requirements.
2. Both the bar-retained or the O-ball retained partial over-dentures improved the retention, stability and function of the prosthesis.
3. The use of the O-ball mini-implants in these situations can be considered a more simplified technique with highly predictable results, as compared to the use of conventional implants.

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