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EARLY LOADING OF SHORT AND STANDARD-LENGTH DENTAL IMPLANTS RETAINING MANDIBULAR KENNEDY CLASS I REMOVABLE PARTIAL DENTURES

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ABSTRACT

Introduction: This study clinically evaluated early loaded short dental implants compared to early long dental implants assisting mandibular Kennedy Class I implant assisted removable partial denture (IARPD) with the implants placed once at the position of the missing first molar once at the position of the missing second molar.

Materials and methods: Twenty male patients, 30 to 60 years old, participated in this study and were blindly divided into 2 groups. The 10 patients of group I received one short implant placed in the mandibular right edentulous space at the site of the missing first molar, and a long implant placed in the left distal extension space at the site of the missing first molar. Group II was made of the same number of patients but with the implants placed at the sites of the missing second molars. After one year of the IARPD loading the implants were evaluated for plaque index, pocket depth, mobility, vertical bone loss, and bone density profile.

Results: No significant differences were detected in plaque index, probing depth, mobility, or vertical bone loss between the implants in the two groups, however, group I implants had more bone density profile than group II implants, especially long implants as compared to short implants.

Conclusion: The long and short implants placed at the location of the missing first molars had more bone density profile values than those placed at the place of the missing second molars, and in both cases long implants showed better bone density profile than short implants.

KEY WORDS: Short dental implants, implant assisted removable partial dentures, early loading.

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INTRODUCTION

Short dental implants, 8 mm or less, have reached a 96% success rate,[1] and were considered less invasive than standard length longer dental implants that might require adjunctive bone augmentation procedures when placed in atrophic ridges,[2] in addition, short implants were thought to improve the prognosis of distal extension implant assisted removable partial dentures (IARPDS),[3] especially when placed in medically compromised patients,[4] and were thought to have a better prognosis when placed in the mandible than in the maxilla.[5]

Whether placed using single or two stage surgical protocol, short dental implants were claimed to have similar failure rates to conventional longer implants,[6] however, implants of 4-7 mm length were advised to be used with caution,[7] in regards to their number, location, inclination, diameter, surface treatment, and type of attachment when used to retain IARPDS in situations of poor bone quality,[8,9] as they were found to have greater risk and lower predictability as compared to longer dental implants.[10] Other studies recommended short implants to be used with vertical bone augmentation similar to those used with standard implants.[11-14] However, in cases of atrophic mandibular partially edentulous ridges, short dental implants were found to have good therapeutic values in medium to long term clinical service,[15] as they improved the RPDS support, retention, and stability.[16-18]

A controversy existed about the position of the implants under distal extension bases, whether to be placed mesially near the principal abutments or more distally towards the end of the saddles, and whether these bases should be used unilaterally, on separate bases, or connected by major connectors.[19-21] Another controversial factor was the type of attachment of the implants to the IARPDS, where the ball abutments were found to transmit the least amount of stress to the implants and abutment teeth compared to locator and magnet attachments, when placed parallel to the most distal abutment, however, with reduced stability due to its greater freedom of movement, yet with more benefits and preservation of supporting teeth and implants when combined with mesially placed abutments.[22-37]

Immediate loading of short implants placed in distal extension edentulous spaces was considered an option in the treatment protocols, once primary stability could be achieved in selected cases,[38-41] also, no significant differences between the conventional loading and immediate loading of short implants were found,[42-45] with either locator or ball abutment attachments in follow-up periods extending from 2 to 12 years,[46-49] with preference of prognosis for implants placed in atrophic mandibles compared to atrophic maxillae.[50-56]

Based on the previously presented data, this study aimed at clinical evaluation of early loaded short dental implants, compared to early loaded conventional long dental implants, supporting mandibular Kennedy Class I IARPDS placed once at the position of the missing first molar once at the position of the missing second molar in the distal extension areas.

MATERIALS AND METHODS

Patient selection

Twenty male patients, 30 to 60 years old, participated in this study after understanding the procedure and having them sign an informed consent. The patient inclusion criteria included: 1) having a Class I Kennedy mandibular arch, 2) Alveolar bone not less than 10 mm height above the inferior alveolar canal, and a minimum ridge width of 6 mm, 3) having a fully dentate maxillary arch, or an arch that could be reconstructed with fixed restorations, 4) nonsmoker, 5) non-diabetic. The patient's exclusion criteria were as follows: 1) smoker, 2) diabetic, 3) chronic cardiovascular disease, 4) bad oral hygiene 5) non responsive to motivation or appreciation of the treatment provided.

The participating patients were blindly divided into 2 groups:

Group I: made up of 10 patients, each received one short one implant (6 mm long and 4 mm width, Astra tech, Dentsply, Sirona, Germany) placed in the right edentulous space at the approximate site of the missing first molar, and a conventional long implant (10 mm long and 4 mm width, Astra tech, Dentsply, Sirona, Germany) placed in the mandibular left distal extension edentulous space also at the approximate site of the missing first molar.

Group II: made up of 10 patients, each received one short one implant (6 mm long and 4 mm width, Astra tech, Dentsply, Sirona, Germany) placed in the right edentulous space at the approximate site of the missing second molar, and conventional long implant (10 mm long and 4 mm width, Astra tech, Dentsply, Sirona, Germany) placed in the mandibular left distal extension edentulous space also at the approximate site of the missing second molar.

Treatment planning

Each of the participating patients had a custom-made treatment plan aimed at ending up with a mandibular arch ready to receive a Kennedy Class I RPD and a reconstructed maxillary occlusal plane up to the upper second molars. Pre-operative clinical and radiographic examinations were conducted, panoramic and peri-apical x-rays were taken for each patient, preliminary impressions of the upper and lower arches were made and mounted on an articulator for further examination of the available inter-arch space, and the orientation of the occlusal plane. The treatment sequence included: periodontal therapy, oral surgery and placement of implant fixtures, restoration of carious teeth, restoration of missing teeth with fixed partial dentures, and surveyed crowns if the restored teeth were in the path of insertion of the RPDS, and finally the patients were provided with a temporary acrylic resin RPD to be used during the healing time after implants placement.

Surgical protocol

A cone beam computed tomography (CBCT) x-ray was made for each patient, the CBCT axial cuts were used to identify the location of the inferior alveolar nerve canal, and to construct a surgical guide with a metal sleeve at the position of implant placement. The patients were premedicated with analgesics/anti-inflammatory, Ketoprufen 150 mg, and antibiotics, Amoxicillin Clavulonic acid 625 mg, the patients were asked to use chlorohexidine mouth wash prior to the procedures. Inferior alveolar nerve block anesthetic, HCL 2% and adrenaline as Levonordefrin 1: 20000, was administered, a crestal incision was made on the edentulous ridge, then a full muco-periosteal flap was reflected. The surgical template was secured in place for drilling the osteotomies. Both long and short implant osteotomies were prepared using a maximum of 1100 rpm high torque motor (Osseoset 200, Nobel Biocare) irrigated with sterile water, and a drill sequence of 2-, 3.2-, and 3.7-mm drills to a depth of 10 and 6 mm respectively. The implants were then placed to an equicrestal position. After placement of both types of implants, as seen in figures 1 and 2, cover screws were secured in place and left uncovered by the gingiva, then the temporary RPD was delivered and relieved over the implant sites, and patients were asked again to use mouth was, and were given post operative care instructions and medications.

Prosthetic protocol and implant early loading

After one week of implants placement, patients were recalled for suture removal and preliminary impressions making, in the following visits final impressions, registration of jaw relationships, try-in of metal frameworks and wax dentures were made using conventional methods. [20, 22, 25, 27, 30, 34] After one month of healing for both long and short implants, the ball abutments were attached to the implants, and after final impressions making, replicas of the ball abutments were secured in the impressions to be part of the master casts over which definitive prostheses were flasked including the metal housing of the ball abutments in the IARPDS metal framework as seen in figures 3-5. The IARPDS had a lingual plate major connector, and combination clasps to relieve the abutments during occlusal loading.

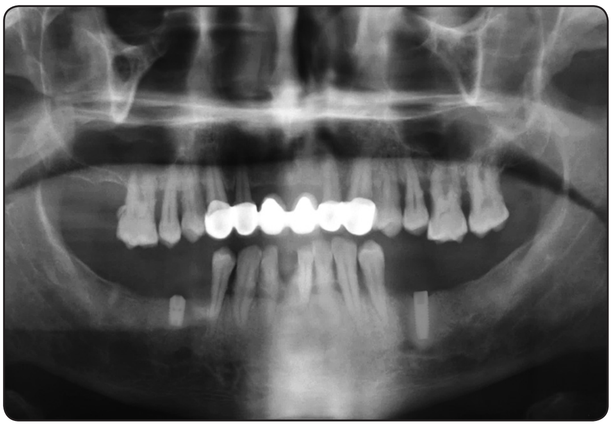

Fig. (1): Immediate post-operative panoramic x-ray of group I, short and long implants placed at the approximate location of the first molar.

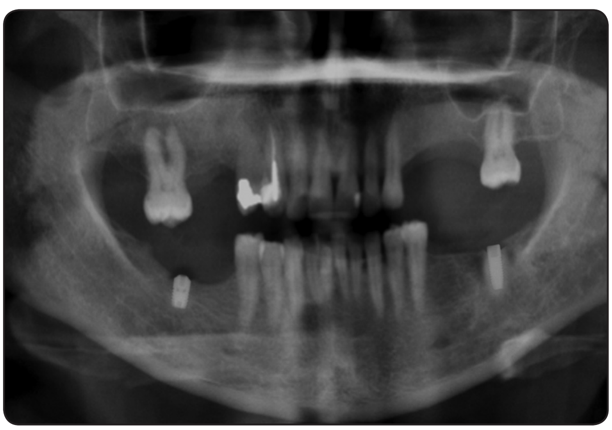

Fig. (2): Immediate post-operative panoramic x-ray of group II, short and long implants placed at the approximate location of the second molar.

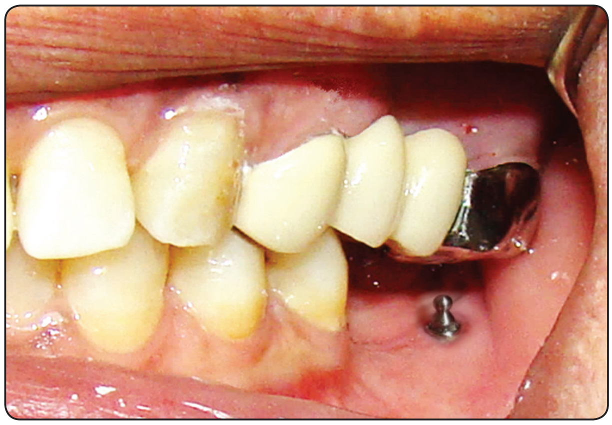

Fig. (3): Group I short implant ball abutment.

Fig. (4): Group II long implant ball abutment.

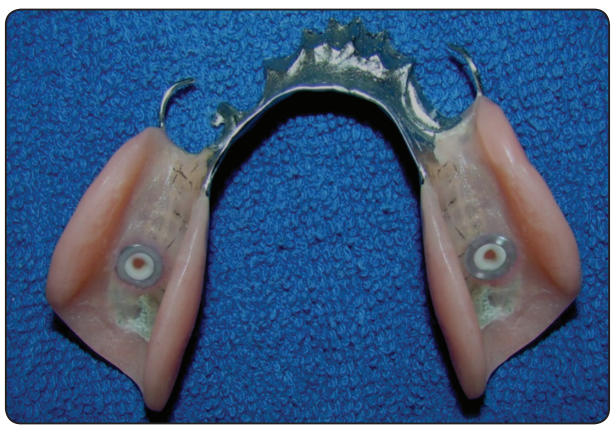

Fig. (5): One of group II definitive prostheses with metal housings and O-rings for the ball abutment in the IARPD intaglio surface.

Patient follow up

The clinical evaluation included study of the plaque index, pocket or probing depth, implant stability using the periotest, and radiographic examination which included determination of the peri-implant vertical bone loss and bone density profile using standardized digital peri-apical x-rays and the ImageJ software. Base line measurements of implant stability and peri-implant bone vertical height and density were made, then patients were followed up after 12 months of prostheses delivery.

For assessment of the vertical bone loss, the x-ray images were opened with the ImageJ software and the following steps were taken:

1. The scale was determined in reference to the known implant length using the set scale command in the software to convert the pixel dimensions to millimeters.
2. The distance from the shoulder of the implant (implant-abutment interface level) to the first visible bone-to-implant contact was determined by linear measurements. In addition, the length of the implant was measured in order to determine the magnification factor in the radiograph as seen in figure 6. The measurements of the bone levels were then adjusted according to the magnification.
3. A line was drawn from the reference point in implant abutment and the first point of bone implant contact, the measurements in mm were noted both mesially and distally and the mean was calculated.

And for assessment of the bone density profile around the implants, the region of interest (ROI), as seen in figure 7, was selected which was in close level to bone implant interface in the mesial (point 1), distal (point 2) and apical (point 3) aspects, and the degree of blackening and whitening (radiolucency and radiopacity) was expressed in numbers from 0 to 255, and the following steps were taken:

1. The rectangle marquee tool was used to make selection of the area including the bone implant interface.
2. Form the "analyze" command in the title bar select "measure" to give mean gray value (mean density)
3. Mean Gray Value (average gray value within the selection) was the sum of the gray values of all the pixels in the selection divided by the number of pixels, then the results were saved

The abutment teeth were at the beginning of the treatment plan and their pocket depth and mobility were registered in the periodontal charts, then after one year of loading the teeth were examined again.

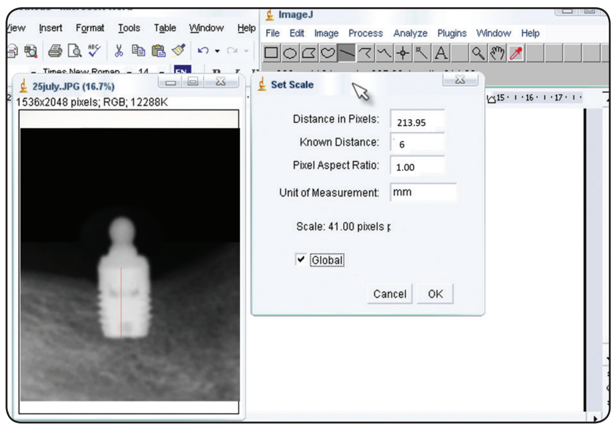

Fig. (6): The use of ImageJ software to determine the peri-implant vertical bone loss

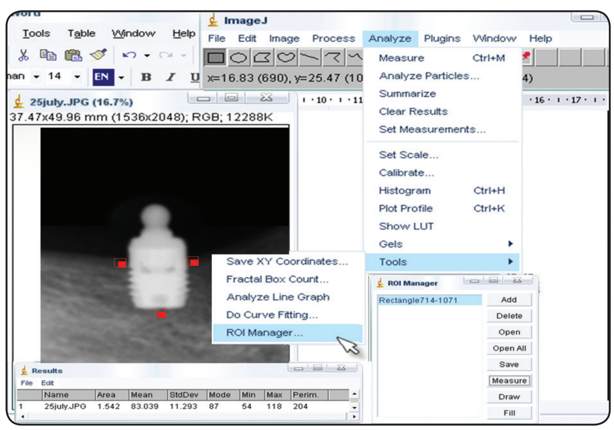

Fig. (7): The use of Image J software to determine the peri-implant bone density profile at three points (red squares), namely: mesial, distal, and apical.

The collected data were tabulated and statistically analyzed using the Paired T test (SPSS version 20 for windows).

RESULTS

1) Plaque index:

In both group I and II, the mean plaque index of short implants was higher than that for long implants, however, these results were statistically insignificant. (Table 1) (Fig. 8)

2) Probing depth:

For group I, the mean probing depth for long implants was greater than that for short implants, however, this result was statistically insignificant. (Table 1) (Fig. 8)

For group II, the mean probing depth for short implants was greater than that for long implants, however, this result was statistically insignificant. (Table 1) (Fig. 8)

3) Mobility:

For both group I and II the mean of periotest readings of short implants was greater than that for long implants, however, these results were statistically insignificant. (Table 1)

4) Radiographic evaluation:

a) Vertical bone loss (mm):

For both group I and II the mean vertical bone loss of short implants was greater than that for long implants, however, these results were statistically insignificant. (Table 1) (Fig. 8)

b) Bone density measurement:

Comparisons within each group revealed that for group I long and short implants the mean bone density profile values at points 1, 2, and 3 after 12 months of loading were significantly greater than its values on the time of loading at the same points respectively, however, these values were significantly greater around long than short implants as seen in tables 2 and 3. The same results were obtained for group II long and short implants, where each category showed increase in its bone density profile at each of the 3 studied points, yet the long implants exhibited significant increase in its recorded bone density profiler values as also seen in tables 2 and 3.

Comparison between groups revealed that long and short implants of group I had significantly greater bone density profile at the same studied points in separate and in overall basis as seen in table 4.

Finally, none of the abutment teeth shoed any increase in pocket depth or increased mobility.

TABLE (1): Descriptive (mean and standard deviation SD) and statistical analysis (p value) of the one year follow up of the short and long implants

		Group I			Group II		
		Long implants	Short implants	p	Long implants	Short implants	p
Plaque index	Mean	1	1.833	0.06	0.813	1.167	0.16
	SD	0.204	0.753		0.239	0.408	
Probing depth	Mean	1.375	1.333	0.88	1.5	1.583	0.75
	SD	0.479	0.408		0.408	0.376	
Mobility	Mean	-6.5	-5.3	0.07	-6.09	-5.4	0.06
	SD	1.23	1.16		1.22	1.12	
Vertical bone loss	Mean	0.625	1	0.08	0.375	0.75	0.15
	SD	0.250	0.316		0.479	0.274	

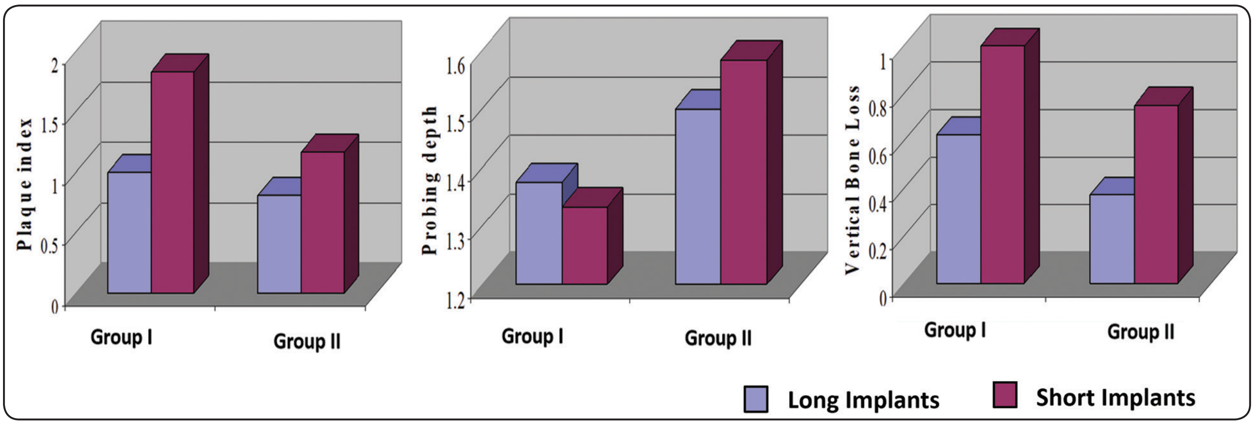

Fig. (8): bar charts of group I and II long and short implants plaque index, probing depth, and vertical bone loss.

TABLE (2): Bone density measurements pre-operatively and at 12 months.

group	Implant	Mean and standard deviation (SD)	At loading			12 months after loading		
			Point 1	Point 2	Point 3	Point 1	Point 2	Point 3
Group I	Long implants	Mean	65	48.4	132.4	152.8	149.8	219.8
		SD	12.83	12.99	29.18	12.68	24.97	9.36
	Short implants	Mean	61	52	145	109	109.2	183.2
		SD	11.95	13.24	32.13	16.31	26.86	9.6
Group II	Long implants	Mean	57	56.8	148.4	95	95.2	196.4
		SD	6	5.8	15.99	5.15	3.11	11.99
	Short implants	Mean	64	51	138	77.8	79.6	170.6
		SD	12.65	4.7	14.56	4.82	6.35	17.6

TABLE (3): Statistical analysis (p value) of bone density profile within each group after one year of loading versus base line measurements at point 1, 2 and 3

Group	Implant type	Point 1	Point 2	Point 3
Group 1	Long implants	0.00	0.01	0.00
	Short implants	0.04	0.01	0.04
	Long versus short implants	0.00	0.01	0.02
Group II	Long implants	0.02	0.03	0.03
	Short implants	0.01	0.00	0.04
	Long versus short implants	0.03	0.04	0.04

P is significant at ≥ 0.05

TABLE (4): Comparison of the bone density profile of all implants of group I versus those of group II after 1 year of loading

Group	Descriptive analysis	Point 1	Point 2	Point 3	Overall
Group I	Mean	130.9	129.5	201.5	
	SD	14.5	25.9	9.48	
Group II	Mean	86.4	87.4	183.5	0.00
	SD	4.98	4.73	14.79	
Statistical analysis	p	0.00	0.01	0.00	

***P* is significant at ≥ 0.05**

DISCUSSION

Xie et al[3] stated that growth of geriatric population increased the number of partially edentulous patients and their demands of removable partial dentures (RPDS). Da Silva et al[17] and Zancopé et al[24] found that dental implants assisting RPDS improved their support, retention, and stability, provided better masticatory performance, and preserved the abutment teeth and their periodontium. Jagadeesh et al[4] reported that short implants provided the same service as long implants under RDPDS in patients with poor bone quantity, and Telleman et al[5] reported that short implants had more success in the mandibles than in maxillae of partially edentulous patients, without any bone augmentation procedures, irrespective of the implant length or surface topography but excluding from these results smoker patients. The current study reported success of short dental implants in assisting IARPDS, with plaque index, probing depth and absence of mobility similar to the long implants used in this study in a split mouth approach. The short implants used in this work had the same diameter, macro-design, and surface treatment as the long implants.

Similar to the results of this study, Sun et al[6] and Lemos et al[7] reported that short implants showed marginal bone loss similar to standard long implants, Torres-Alemany et al[13] Further stated that the parameters of implant length, diameter, or crown/ implant ratio have not been established as being statistically significant in terms of its influence on bone or implant loss. However, this finding came in contrast to Papaspyridakos et al[10] who claimed that short implants had higher rates of failure in 1 to 5 years of service as compared to conventional long implants, especially when the short implants length was less than 6 mm, or more generally less than 10 mm as indicated by Abdel-Halim et al.[14]

In contrast to Alam-Eldein et al[20] who suggested unilateral RPDS to restore class II Kennedy arches, this study used conventional design RPDS having major connectors to counteract the effects of unilateral loadings through cross arch stabilization as advocated by the finite element study of Messias et al[21], and further confirmed by Shahmiri et al[19,36] who found that unilateral occlusal loading generated vertical and lateral displacements of the IARPD, and resulted in destructive stresses to the prostheses and supporting abutments. Shahmiri et al[19] also found that bilateral loading minimized the lateral distorting forces, but placed more strains in the occlusal rests of the principal abutments as the load moved more mesial, this finding verified the results of this study in regards to the placement of the implants in the place of the missing first molar rather than the second molar, as the vertically applied bilateral loading was along the long axes of the principal abutments, and the implants that were placed parallel to them, and being within the limits of the physiologically tolerated loads, the bone density profile of the mesially placed implants was more than the distally placed ones. Hegazy et al,[21]in contrast to the findings of this study, suggested distal rather than placement of the implants, however, in His study, the mesially placed implants were in the premolar region, where as the mesially placed implants in this study were in the first molar region that was surrounded by thick cortical plates that dissipated the vertically applied loads, in contrast to the distally placed implants that suffered longer effort arms and more lateral twisting loading exaggerated by the upward curvature of the distal extension saddles as they approach the retromolar pads as confirmed by ELsyad et al,[30] and Alkhodary[34] who found that distal placement of implants, beneath distal extension partial overdentures, recorded significantly higher stresses than with their mesial placement.

Khaki and Shishehian[26] found that ball abutments, similar to those used in this study, resulted in lower stability of the IARPD due to its greater freedom of movement, however, Omar et al[22] and ELsyad et al[32] reported that ball attachment used to retain IARPD recorded the lowest strain around abutment teeth compared to locator and magnetic attachment. Liu et al[46] further added that both locator and ball attachments helped minimize the marginal bone loss around immediately loaded un-splinted implants retaining mandibular overdentures.

Immediate loading of short implants was reported in several studies of Alvira-González et al[38], Weerapong K et al[42], and Hadilou et al.[45] However, this study adopted a more careful approach, the early loading, based on previous studies on the mandibular numerical models,[37] and bone density in the posterior mandible, [43,49,57] where the achieved primary stability of the short dental implants, together of one months of healing, the vertical placement of the implant, and the resilient attachment, enabled the short implants used in this study to demonstrate vertical bone loss values and surrounding bone density profile similar to the standard conventional long implants.

In conclusion, the overall one year follow up results of this study were in agreement with several other studies, where in a retrospective study of 124 cases, Grant et al[47] found that short implants were able to provide an effective alternative to long implants in cases of atrophic posterior mandibles and helped to avoid bone grafting and mandibular nerve re-positioning. The same results were confirmed by El Mekawy et al,[48] and Faot et al[51]who used short implants in a split mouth approach similar to that used in this study, however, his implants were splinted, and Guida et al[52] who used short implants in completely edentulous patients. The previously mentioned follow up findings were further confirmed by the results of Banihashemrad et al[54] study on the stability of short implants compared to long implants using also the periotest, where the short implants showed a similar stability, and provided a successful alternative to long implants, as well as improved the patient psychology and prostheses performance as proved by Bellia et al[55] and Pardo-Zamora et al.[56]

Finally, the limitations of the current work included some parameters that were recommended to be investigated in future research such as: involvement of larger number of patients and following them up for longer periods of clinical service, using resilient attachments of different forms and heights of to retain the IARPD, and investigating the effect of the available inter-arch space on the choice of these attachments together with the mechanical behavior of the overlying prostheses.

CONCLUSION

Taking the limitations of the current work into account, the following conclusions were listed:

1- After one year of clinical service, the early loaded short implants placed at the locations of the missing first and second molars successfully retained the IARPD similar to the standard-length long implants without failure.

2- The long and short implants placed at the location of the missing first molars had more bone density profile values than those placed at the place of the missing second molars, and in both cases long implants showed better bone density profile than short implants.

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