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Original Article

Bone Loss and Prosthetic Complications With Short and Narrow Diameter Implants Used to Retain Mandibular Implant Overdentures: A Randomized Clinical Trial

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Abstract

Aim: This study aimed to compare marginal bone loss between narrow diameter implants (NDIs) and short implants in implant-retained mandibular overdenture patients, using cone beam computed tomography (CBCT).
Subjects and methods: Eighteen completely edentulous patients with compromised mandibular ridges were categorized into two groups: Group (I) had two NDIs and Group (II) had two short implants supporting mandibular overdentures. CBCT was used to estimate peri-implant bone loss for each case at the loading time, six months, one year, two years, and three years follow-up.
Results: Bone loss means from zero time till 6 months was 0.93 mm in group (I) and 0.69 mm in group (II). And from 6 months to 1 year, the mean was 0.36 mm in group (I) and 0.43 mm in group (II). The mean from 1 year to 2 years period was 0.25 mm in group (I) and 0.29 mm in group (II). The mean in the period from 2 years to 3 years was 0.09 mm in group (I) and 0.06 mm in group (II). The mean difference throughout the three years was 1.30 mm in group (I) and 1.28 mm in group (II).
Conclusion: There was no statistically significant difference in peri-implant marginal bone loss between mandibular overdentures using NDIs and those using short implants, although NDIs showed a slightly higher bone loss.

Keywords: Implant overdenture, short implants, narrow diameter implants, CBCT.

Introduction:

The transition from dentulous to edentulous state poses various difficulties to the patient and the clinician as well. Bone resorption distinctly in the mandible is a significant factor to be considered during the restoration procedure, which may be considered a tricky test.[1] Untreated edentulism is considered a major public health problem, and in a socioeconomically backward population, treatment expense is one critical determinant of individual oral health status.[2]

Conventional removable prostheses need ceaseless changes and adaptations, even after adjustment, it is not tolerated by many patients. Implant-borne prostheses are regularly the first option for completely edentulous cases, as they have numerous advantageous impacts like further developed maintenance, stability, capacity, proprioception, and solace. Also, implants used to restore edentulous mandibles can restrict bone resorption to a large extent.[3] Implant overdentures fulfill the patient's

anticipations and work on their satisfaction with the prosthesis's versatility.[1]

As it is known that the longer the implant the better the prognosis, however, in many circumstances, placement of long implants is hindered by anatomical limitations, especially in the atrophic mandible with minimal bone width and height.[4,5] Short implants maybe occasionally the solution to those cases, having several advantages over standard implants; in which less vertical bone grafting is required, meaning decreased time and expense of treatment and less patient morbidity. Thus, less surgical risk of perforating the maxillary sinus, provoking paresthesia due to nerve injury, and injuring adjacent teeth roots.[6,7,8]

The European Consensus Conference on short implants found them to be a reliable treatment line, given the risks correlated with augmentation procedures.[9] Modern innovations in implant materials, also micro and macro-structural design technologies have made it attainable to manufacture dental implants with a larger surface area despite their short length.[10-12]

The term narrow diameter implants (NDIs) is referred to implants with a diameter <3.4mm.[13] The NDIs have a diameter between those of mini and conventional implants, thus having some features of both, therefore they can be called hybrid or medi-implants.[14]

The NDIs are considered a feasible alternative in clinical situations with horizontal space limitation problems, which do not permit the use of standard or wide-diameter implants.[15] Their small diameter may be utilized for augmenting the retention of dentures in patients with limited bone width and improving their quality of life.[16] They have numerous advantages including the capability to be placed in narrow ridges, simplified treatment procedures, placed through a flapless surgical technique alleviating postsurgical discomfort and morbidity for patients, also designed as a one-piece implant to immediately load the prosthesis and provide treatment benefits to the patient in a single clinical visit.[17]

Some researchers claim that NDIs originally, have been associated with high rates of failure compared with regular and wide implants since they generate an unfavorable stress distribution in peri-implant bone.[18]

This study aims to compare marginal bone loss between narrow diameter implants (NDIs) and short implants in patients rehabilitated with implant-retained mandibular complete overdenture, using cone beam computed tomography (CBCT). The hypothesis was that NDIs will cause more peri-implant bone resorption than short implants.

Subjects and Methods:

Study population:

Eighteen patients were randomly selected from the outpatient clinic, Faculty of Dentistry, Ahram Canadian University. Patients in this study had the following inclusion criteria: completely edentulous, atrophied, or resorbed mandible with an average height and width detailed in the patients grouping section, age range 50-65 years, free from chronic systemic diseases, non-smoking individuals, with sufficient inter-arch distance, healthy, firm non-atrophied or hyperplastic soft tissues, average mouth opening, good neuromuscular control, and normal maxilla-mandibular relation.

Exclusion criteria: patients taking any hormonal medication affecting bone resorption, any oral pathological condition, uncooperative patients, or the presence of any psychological disability.

Sample size calculation was performed using G Power program, University of Düsseldorf, Düsseldorf, Germany. At least 16 subjects were needed to accomplish the study to give a power of 80% then two subjects were added to account for any dropout which represents the remaining 20%[19].

All patients signed a written consent demonstrating they were willing to participate in the study and complete the follow-up period of three years.

Based on the diagnostic CBCT, patients were categorized into two groups according to the bone height and width which controls the type of implants used as follows:

Group (I): 9 patients had thin mandibular ridges with an average width of 5 mm., and height of at least 14 mm. Each patient received two narrow diameter one-piece implants in the mandibular canine's region with 11.5mm length and 3mm diameter [Implant Direct Syborn international (Go Direct system). 3050 E Hillcrest Dr, Thousand Oaks, California, 91362, U S.]. Group (II): 9 patients had vertically resorbed mandibular ridges with an average height of 10 mm., and width of at least 7 mm. Each patient received two short one-piece implants in the mandibular canine's region with 8mm length and 4.7mm diameter [Implant Direct Syborn international (Go Direct system). 3050 E Hillcrest Dr, Thousand Oaks, California, 91362, U S.].

The attachment used in both groups was the Locator type which is suitable because of its low vertical height and dual retention property. Nylon retention inserts present an internal extension engaging into a socket on the top of the locator abutment. The retention obtained from the internal and external features of the abutment is considered dual retention.

Both groups received maxillary and mandibular complete dentures and had a one-month follow-up period and adjustments of the dentures before implant insertion. Standard clinical and laboratory techniques were followed for the construction of the dentures for all patients. The same operator and laboratory technician performed all the denture steps.

A clear acrylic stent was constructed from the mandibular denture duplication and then used to plan the position of the implants by gutta-percha points on the diagnostic CBCT [i-CAT; Imaging Sciences International LLC.1910 North Penn Road Hatfield, PA.19440. USA] shown in (figure 1), is also used as a guide to insert implants in the proper position and correct angulation during the surgical procedure as shown in (figure 2).

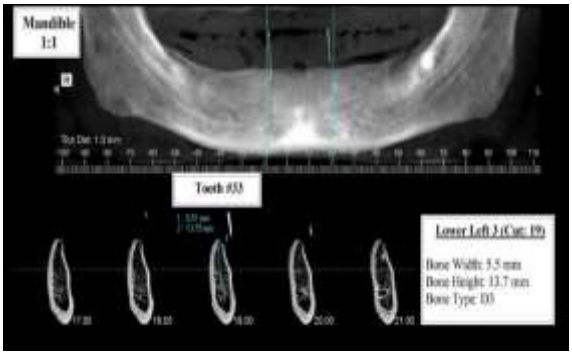


Figure (1) Diagnostic CBCT showing potential implant position with gutta-percha points

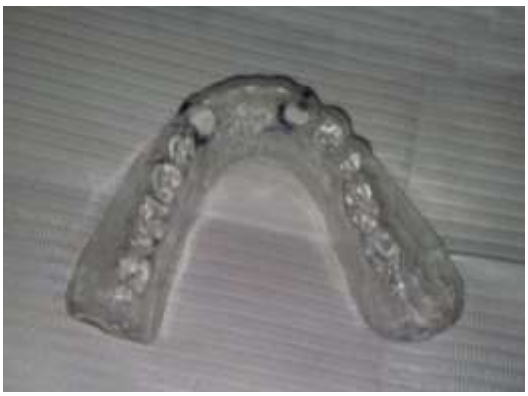


Figure (2) Showing surgical stent

Surgical procedures:

Anesthesia was given, then a punch instrument was used to remove soft tissues at the implant sites as a flapless technique was adopted. The surgical kit was used to select the proper drills to drilling implants sites, then implants were inserted and threaded into the bone in a clockwise direction under saline irrigation until its top flush with the bone surface using torque-controlled ratchet device and secured in position with good

primary stability (figure 3 and 4).

Figure (3) Showing implant insertion

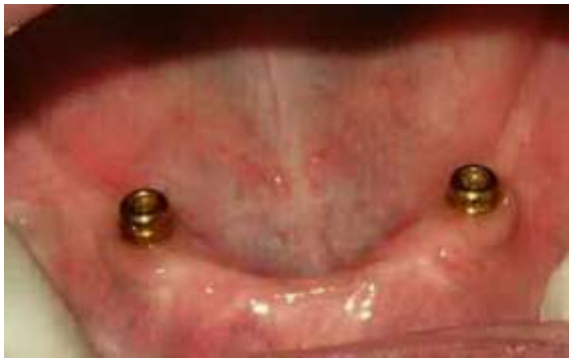


Figure (4) Shows the two implants in position

A minimum of 35Ncm insertion torque was required for the immediate loading of the implants. Postoperative medication was prescribed, and oral hygiene measures were emphasized.

Immediate loading of the implants was conducted within the first week after surgery. The mandibular denture fitting surface was relieved opposite to the implant sites, then the housings including nylon retention caps were inserted in position to load the implant attachments as shown in (figure 5). Follow-up appointments were scheduled for all patients.

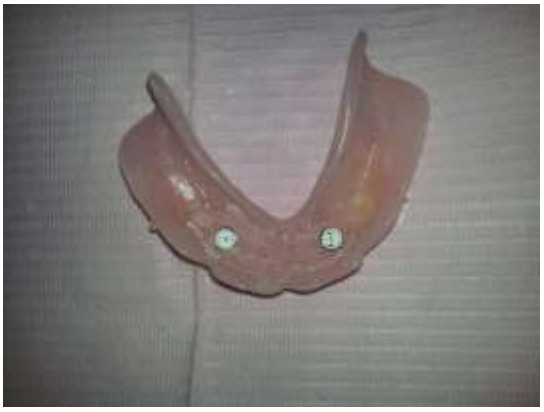
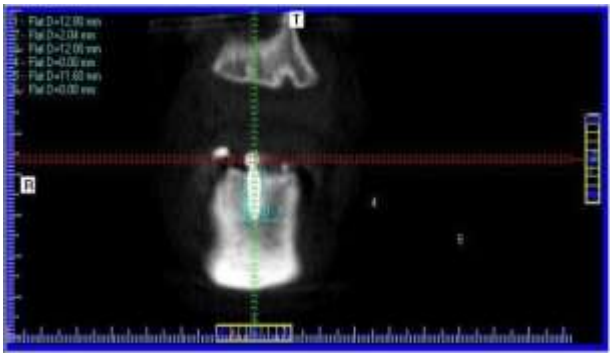


Figure (5) Shows the mandibular denture fitting surface with the two housings & retention caps

Radiographic assessment:

The implant's marginal bone loss was evaluated as the primary outcome of the study. The patients were radiographically evaluated after loading the implants (zero time), then after six months and at one, two, and three years of function. CBCT was used for the evaluation and bone height measurements. The exposure parameters were standardized, and the implants were bisected mesiodistally and buccolingually in the axial views of the reconstructed images. The resultant images give a panoramic view of each implant that allows evaluation of the axial bone loss. Examination of marginal bone loss was conducted by measuring peri-implant bone height at mesial, distal, lingual, and buccal sides around the implants at each measuring time, using the linear measurement system of the software. The marginal bone level was the distance between the highest implant-bone contact and the most apical bone-implant contact, which was obtained by lines drawn around the implants and revealed by the CBCT software in millimeters as shown in (figure 6). Calculations of bone loss of right and left implants were averaged, and the mean was subjected to statistical analysis.



(Figure 6) Showing linear measurements of marginal bone height performed using CBCT software

Prosthetic complications:

Prostheses survival was also evaluated as a secondary outcome measure (considering the necessity of replacing the prosthesis). Any adjustments were performed and checking for any problem that necessitates the replacement of the prosthesis was performed at each evaluation date. Prosthetic problems included mechanical complications with the dentures, implants, and attachments. Soft tissue problems such as ulceration, soreness, flabbiness, or hyperplasia.

Statistical analysis:

All numerical data obtained were collected and

tabulated for each surface of each implant at the

Period	0 - 6 Month		6 - 12 Month		1 - 2 Years		2 - 3 Years		0 – 3 Years	
	Mean	Std.	Mean	St. d.	Mean	St. d.	Mean	St. d.	Mean	St. d.
Mesial	0.82	0.12	0.45	0.09	0.28	0.04	0.09	0.02	1.33	0.18
Distal	1.02	0.13	0.29	0.06	0.21	0.05	0.05	0.03	1.23	0.22
Buccal	0.83	0.1	0.39	0.13	0.27	0.06	0.12	0.02	1.31	0.17
Lingual	1.04	0.11	0.32	0.07	0.24	0.04	0.08	0.02	1.32	0.26

Table (1) shows the mean and standard deviation of the bone loss for each implant surface in different periods for group (I)

different times of evaluation. Mean and standard deviation were calculated. The independent sample T-test was used for comparison between the two groups and the repeated measure ANOVA test was used to compare between the follow-up periods. The significance level was $P \leq 0.05$. The software used was IBM SPSS Statistics version 23, Inc., Chicago, IL, USA.

Period	0 - 6 Month		6 - 12 Month		1 - 2 Years		2 - 3 Years		0 – 3 Years	
	Mean	Std.	Mean	Std.	Mean	Std.	Mean	Std.	Mean	Std.
Mesial	0.76	0.06	0.48	0.1	0.18	0.1	0.07	0.04	1.36	0.14
Distal	0.61	0.08	0.40	0.11	0.27	0.08	0.05	0.02	1.17	0.15
Buccal	0.78	0.07	0.41	0.09	0.14	0.11	0.05	0.03	1.38	0.19
Lingual	0.59	0.08	0.42	0.12	0.2	0.07	0.06	0.04	1.19	0.14

Table (2) shows the mean and standard deviation of the bone loss for each implant surface in different periods for group (II)

Results:

All the patients accomplished the study protocol along the 3 years follow-up period.

Peri-implant bone loss throughout time:

Group (I):

(Table 1) shows the mean and standard deviation of peri-implant bone loss in each surface during the follow-up periods for group (I).

The mean of the peri-implant bone loss after six months of loading on the mesial surface was 0.82 ± 0.12mm, the distal surface was 1.02 ± 0.13mm, the buccal surface was 0.83 ± 0.1mm, and the lingual surface was 1.04 ± 0.11mm.

As for the next period from 6 months to 1 year the mean of bone loss on the mesial surface was 0.45 ± 0.09mm, on the distal surface was 0.29 ± 0.06mm, on the buccal surface was 0.39 ± 0.13mm, and on the lingual surface was 0.32 ± 0.07mm.

The mean of bone loss through the period from 1 year till 2 years, on the mesial surface, was 0.28 ± 0.04mm, on the distal surface was 0.21 ± 0.05mm, on the buccal surface was 0.27 ± 0.06mm, and on the lingual surface was 0.24 ± 0.04mm.

The mean of bone loss through the period from 2 years to 3 years, on the mesial surface was 0.09 ± 0.02mm, on the distal surface was 0.05 ± 0.03mm, on the buccal surface was 0.12 ± 0.02mm, and on the lingual surface was 0.08 ± 0.02mm.

The mean of bone loss throughout the whole study period from loading time to 3 years, on the mesial surface was 1.33 ± 0.18mm, on the distal surface was 1.23 ± 0.22mm, on the buccal surface was 1.31 ± 0.17mm, and on the lingual surface was 1.32 ± 0.26mm.

Group (II):

(Table 2) shows the mean and standard deviation of peri-implant bone loss in each surface in the follow-up periods for group (II).

The mean of the peri-implant bone loss after six months of loading in the mesial surface was 0.76 ± 0.06mm, on the distal surface was 0.61 ± 0.08mm, on the buccal surface was 0.78 ± 0.07mm, and on the lingual surface was 0.59 ± 0.08mm.

As for the next period from 6 months to 1 year the mean of bone loss on the mesial surface was 0.48 ± 0.1mm, on the distal surface was 0.40 ± 0.11mm, on the buccal surface was 0.41 ± 0.09mm, and on the lingual surface was 0.42 ± 0.12mm.

The mean of bone loss through the period from 1 year to 2 years, on the mesial surface was 0.18 ± 0.1mm, on the distal surface was 0.27 ± 0.08mm, on the buccal surface was 0.14 ± 0.11mm, and on the lingual surface was 0.2 ± 0.07mm.

The mean of bone loss through the period from 2 years to 3 years, on the mesial surface was 0.07 ± 0.04mm, on the distal surface was 0.05 ± 0.02mm, on the buccal surface was 0.05 ± 0.03mm, and on the lingual surface was 0.06 ±0.04 mm.

The mean of bone loss through the whole study period from loading time to 3 years, on the mesial surface was 1.36 ± 0.14mm, on the distal surface was 1.17 ± 0.15mm, on the buccal surface was 1.38 ± 0.19mm, and on the lingual surface was 1.19 ± 0.14mm.

(Table 3) shows the mean (mean bone loss around the 4 peri-implant surfaces), standard deviation, and P value in each group in the 4 follow-up periods and for the whole three years follow-up period. The bone loss mean from the time of loading till 6 months was 0.93 ± 0.08mm in group (I) and 0.69 ± 0.04mm in group (II). As for the period from 6 months to 1 year the mean was 0.36 ± 0.02mm in group (I) and 0.43 ± 0.04mm in group (II). The mean from 1 year to 2 years period was 0.25 ± 0.01mm in group (I) and 0.29 ± 0.06mm in group (II). The mean in the period from 2 years to 3 years was 0.09 ± 0.01mm in group (I) and 0.06 ± 0.01mm in group (II). As for the mean difference in peri-implant bone loss throughout the whole three years period, it was found to be 1.30 ± 0.10mm in group (I) and 1.28 ± 0.12mm in group (II).

The calculated mean of bone loss differences between the two groups at the end of the follow-up period was slightly higher with group (I) having NDIs than group (II) having short

implants, but the difference was not statistically significant ($P \leq 0.05$).

The most frequent prosthodontic problem observed was the wear of the attachment housing, followed by overdenture relining. As for soft tissue complications, soreness and ulceration were the most common problems observed.

As for the overdenture survival difference, there was no difference in the number of maintenance performed in both groups and all prostheses performed well throughout the three years study with no major problems or replacement of any denture as shown in (Table 4).

Period	0 - 6 Month		6 - 12 Month		1 - 2 Years		2 - 3 Years		0 – 3 Years	
	Group (I)	Group (II)	Group (I)	Group (II)	Group (I)	Group (II)	Group (I)	Group (II)	Group (I)	Group (II)
Mean bone loss for the 4 surfaces	0.93	0.69	0.36	0.43	0.25	0.29	0.09	0.06	1.30	1.28
St. d.	0.08	0.04	0.02	0.04	0.01	0.06	0.01	0.01	0.10	0.12
P value	<0.0001		0.0001		<0.0001		<0.0001		0.8582	

Table (3) shows the mean bone loss around the 4 peri-implant surfaces, standard deviation, and P value along the different time periods

Prosthetic complication	**Group I**	**Group II**
Attachment fracture	1	1
Wear of housing	7	5
Dislodgment of housing	2	1
Overdenture fracture	0	0
Overdenture relining	3	4
Soreness	2	2
Ulceration	2	1
Flabby tissues	0	0
Hyperplasia	0	0

Table (4) shows prosthodontic complications in both groups

Discussion:

In the present study, peri-implant bone resorption was found to be with no significant difference between the two types of implants tested despite the slightly higher resorption found in NDIs, which makes us reject our hypothesis of NDIs causing considerably higher peri-implant bone resorption than short implants.

Proper implant positioning has numerous advantages, including long-term durability of

peri-implant hard and soft tissues, enhanced oral hygiene, achieving ultimate occlusion, and better aesthetic outcomes.[20] In the present study, inserting the implants in the proper position was mandatory to decrease the risk factors as possible, also the implants were placed in position using a surgical guide to increase success chances, as a study states that implants placed using guided surgery exhibited higher survival rates and enhanced long-term cost when compared with non-guided implant placement.[21]

Using only two NDIs at the canine regions to support and retain mandibular overdenture proved to be a successful treatment by many researchers,[22,23] thus we could unify the number of utilized implants in both research groups to be two implants thus decreasing the variables.

The immediate loading protocol was followed in this study, as the results of several other studies revealed no significant difference between immediate and delayed implant loading.[24,25]

One-piece implant systems were used to diminish crestal bone loss based on the theory that contamination of the implant-abutment junction or the micro-gap, and violation of the biological width are the originators of the initial bone loss in two-piece implants,[26] that is why one-piece implants were used in this study.

In this study, implants were placed following the flapless technique in all cases as this technique is suitable for immediate loading protocol, also research states it causes less tissue trauma, reduces overall treatment time, reduces patient anxiety and discomfort, induces patient acceptance, with better function and aesthetics.[27]

CBCT is a favorable imaging technique for computing peri-implant bone. It has been stated that CBCT provides usable information about bone in all dimensions around implants and bone geometry can be detected accurately near the implant surface.[28,29] That's why peri-implant bone height was measured using CBCT in this research.

The normal bone loss rate is stated to be about 1.2mm in the first year, meaning most of the bone loss, especially in the first six months.[30] Within the first 6 months the bone loss could be attributed to the normal biologic process of bone remodelling occurring after implant insertion, and instant bone response to healing and reorganization combined with function loads.[31] In the present study, follow-up and evaluation of bone loss were conducted for three years to detect the effect of longer than the first-year time on peri-implant bone loss.

Short implants were assessed because they can be used in jeopardized (decreased height) residual ridges to avoid increased morbidity due to the surgical procedures needed. As stated, short implants do not have a significant impact on marginal bone loss and the survival rate of implants.[7,32] Some studies also concluded that the survival rate of short implants is the same as that of regular implants placed through bone regeneration procedures,[33-38] which is in agreement with the results of this study that shows the acceptable outcomes of short implants throughout the three years follow-up, with an average amount of peri-implant bone resorption.

On the contrary, short implants have been linked with a lower survival rate, with unpredictable results. Also, it was stated that short implants with ≤6 mm in length should be attentively utilized because they may present a greater failure risk compared to implants longer than 6 mm.[39] These studies disagree with our results due to the advancements in implant production technologies, as some recent studies stated that a crucial factor inducing the success of short implants is surface treatment or modification, which not only increases surface area, but may also change cell morphology to enhance osteointegration, and contributes to overcoming the adverse effects of short length.[10-12] Another research claimed that the implant diameter can be considered a more effective design parameter than the implant length, in controlling the overloading risk.[40]

As for the NDIs, requiring limited osteotomy preparation, the blood supply at the osseous crest is not remarkably jeopardized as it happens with the larger implants causing the characteristic resorption to the first thread phenomenon seen with them, and this phenomenon doesn't seem to occur with NDIs.[41] These characteristics of NDIs were the reason we have chosen them to be tested in

comparison with short implants in this research.

It was noted too that the survival rate of small-diameter implants appears to be comparable to that of regular-diameter implants with the minimally invasive property.[16,41] These results are in accordance with the results of this study demonstrating the outstanding outcomes and survival rate of the NDIs.

Some studies based on finite element analysis (FEA) established that narrow implants induce higher stress and strain levels at the peri-implant bone level when compared with conventional diameters, anticipating a higher rate of bone loss.[42,43] Overloaded volume in the peri-implant areas exhibits a reduction when the implant diameter is widened. Thus, the contact area between the implant and the bone increases, and hence the load per unit area transferred to the peri-implant tissues is decreased, leading to more favorable stress distribution in the surrounding bone. This explains why NDIs are associated with higher overloading risks compared to regular implants.[42,43] Even splinted NDIs supporting all-on-four prostheses led to a higher risk of overloading than regular diameter implants.[18] Despite these studies' results, we found that NDIs had comparable survival rates and average peri-implant bone loss.

A previous study stated that there wasn't a significant difference in marginal bone loss around mini-implants and short implants, although the bone loss was slightly more around mini-implants than around short implants.[19] These conclusions agreed with this study's results. On the contrary, another study stated that mini dental implants have a more favorable effect on the supporting structures than short dental implants in both clinical and radiographic evaluation.[44]

Several studies reported no difference in the number of prosthesis failures while using short implants or long implants. [36,45-48] This was in accordance with the results of our study which confirmed that the prosthesis survival rate was as satisfactory in both study groups.

The limitations of this study were, having a small number of patients included, a moderately short follow-up period, not including clinical outcomes, not calculating bone volume, nor calculating the cost-effectiveness of the treatment.

Conclusion:

Within the limitations of this study, it was concluded that there was no statistically significant difference in peri-implant marginal bone loss between mandibular overdentures using NDIs, and those using short implants, although NDIs showed a slightly higher bone loss.

Conflict of Interest:

The authors declare no conflict of interest.

Funding:

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Ethics:

The present study was conducted according to the principles embodied in the Helsinki Declaration, revised in 2008, for biomedical research involving human subjects.[49] The study was approved by the ethical committee of the faculty of dentistry Ahram Canadian University (Approval No IRB00012891#22).

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