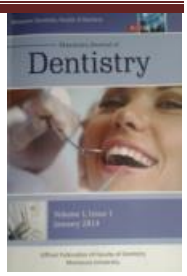

Effect of different implant number and distribution used to retain maxillary overdenture: A study of Peri-implant interleukin-1β.

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Abstract:

Objectives: This study was conducted to compare between different implant number and distribution designed for assisting maxillary complete overdenture regarding the peri-implant IL-1β activity.

Materials and Methods: Six completely edentulous patients were selected for this study. All patients received conventional complete dentures. After inserting the four implants for assisting the maxillary dentures and according to delayed loading protocol, the patients were divided randomly into three groups, Group A: 2 patients started the study with two exposed implants in the canine areas bilaterally to retain maxillary overdenture Group B: 2 patients started the study with two exposed implants located in premolar areas bilaterally. Group C: 2 patients started the study with four exposed implants, located in the canine and premolar areas bilaterally. All implants were attached to the maxillary overdentures through OT equator attachments. Evaluation of peri-implant tissue was done 2 weeks, 3 months and 6 months after insertion of definitive overdenture. This was done by clinical evaluation of the peri implant tissues and by measuring the IL-1β values in the peri-implant sulcular fluid.

Results: When comparing IL-1β values in PISF within each group in all intervals of study, there was a significant increase in values. When comparing between the three groups regarding the total means of IL-1β values around all implants along the T1 and T2 intervals, there was a significant difference.

Conclusions: Within the limitation of this short term study, it is possible to conclude that: assisting the maxillary complete overdenture by four widely distributed implants retained by OT-Equator attachment can be considered more favorable than using only 2 implants either in the canine areas or in the premolar areas regarding the peri-implant IL-1β activity and the clinical evaluation.

Keywords: Implants, Maxillary Complete Overdenture, OT equator attachment, interleukin 1 beta.

Introduction

Normally, maxillary conventional complete denture is supported by soft tissues that have a degree of differential compressibility. This compressibility may be a favorable or unfavorable factor regarding the load transfer characteristics that control the impact on the underlying tissues.(1)

The use of implant to support the maxillary denture negates the soft tissues because the implants are essentially immobile. Vertical loading of the implant provides no displacement of the prosthesis toward the tissues unless specific components are selected to allow movement toward the underlying tissues.(1)

When designing the maxillary overdenture, it must be decided whether to allow or to prevent tissue ward movement, because either course has advantages and disadvantages. Movement of the overdenture toward the tissue is generally favored when implants are not distributed through the arch. If the implants are placed in the anterior maxilla, the prosthesis will fulcrum over the implant as it compresses the posterior tissues under functional load. Consequently, the terminal implants are subjected to adverse stress condition. In this situation, if a rigid retentive component is used to retain the overdenture, the terminal implants experience torsional forces that could lead to component failure or could contribute to implant failure.(1)

On the other hand, the application of three or four implants creates an angular relationship between the implants instead of a straight-line relationship. The most anteriorly positioned implants may provide indirect retention for the denture by preventing the intrusion of the anterior portion of the denture towards the tissues. However, the nature and the anatomy of the maxillary bone may complicate the fair implants axial parallism and distribution.(2)

Sadowsky(3) recommended that a number of 4 implants was the minimum to support a maxillary overdenture and 6 implants in case of compromised bone. Balaguer et al.,(4) found that the number of implants placed in the maxilla had a significant influence on long-term survival, the survival rate of 6 implants being 100%, while survival on 4 implants is as low as 85.7%. However; it was reported that using only two implants in the maxilla did not compromise the prostheses longevity or patient satisfaction when compared with four implant overdentures.(5)

Klemetti(6) concluded that using only two implants in the maxilla did not compromise the prostheses longevity or patient satisfaction when compared with four implant overdentures. More implants may not produce better results and there are definite economic and surgical benefits for patients if a smaller number of implants can be used to obtain predictable clinical outcomes.(7)

The rationale behind the use of distally inclined implants in the all on 4 concept was to by-pass the vital structures and to increase the antero-posterior spread thus eliminate the need

for increased implant numbers without jeopardizing the biomechanics of load transfer to the supporting tissues.[8]

Products in the connective tissues within the alveolar bone and the peri-implant soft tissues can be studied in the PISF in order to monitor the peri-implant tissue health. Biochemical method of evaluating implant durability using the levels of interleukin-1 β in soft tissues adjacent to implants have been documented.[9]
This within patient cross over study was aimed to compare the peri implant tissue health changes of different implant number and distribution used to assist maxillary complete overdenture.

Materials and methods

Six completely edentulous healthy patients were selected from the outpatient clinic of prosthodontics department, faculty of dentistry, Mansoura University. All patients participated in this study were class I angles' classification, free from any systemic diseases contraindicating surgical implant placement, having sufficient bone quality and quantity, non-smokers, free from any local predisposing factors like remaining roots or local infections and free from any parafunctional habits like bruxism. According to the standard procedures, a conventional complete denture was constructed and duplicated into auto polymerized acrylic resin to be used as a radiographic template. Through the cross-sectional images of the CBCT, the implant position and angulation was designed using the accompanying software. A streolethographic surgical guide was constructed using STL files and rapid prototyping technique. Two-stage surgical flapless technique and delayed loading protocol were followed in this study. After administration of local anaesthesia the surgical guide was fixed in the maxillary arch by inserting three anchor pins. Tissue punch was used to cut-off the soft tissue overlying the crest of the ridge Then the osteotomy was prepared using a successive drills according to manufacturer's directions by installing four implants to assist the maxillary prosthesis with two axially parallel implants in the canine areas and two 30 degree distally inclined implants in the second premolar areas bilaterally. Post insertion panoramic x-ray was performed for evaluation of the position and angulation of the inserted implants. The maxillary denture was relieved opposite to implant sites and relined using tissue conditioner that was replaced by soft liner after one week during the six months osseo-integration period of the implants. According to the implant loading after the second surgical stage, the patients were classified to follow a cross over study (of total 18 months study period) into three groups according to the number and distribution of implants retaining the overdenture as follows: The six patients were randomly started according to the number and distribution of implants retaining the maxillary overdenture as follows:
Group A: two patients start the study with two implants exposed in the canine area bilaterally to retain maxillary overdenture.
Group B: two patients start the study with two implants exposed in the premolar area bilaterally to retain maxillary overdenture
Group C: two patients start the study with four implants exposed in the canine and premolar area bilaterally to retain maxillary overdenture

Each patient was converted from group to another group based on implant number and location with 2 weeks rest period during which cover screws were re-screwed and the maxillary denture was relieved with soft liner opposite to the implants.
After six months of osseointegration the gingiva overlying the implants was uncovered. Cover screws were replaced with the Equator abutments (fig1). Rubber dam sheet was punched and placed over the blocking-out disk around the equator abutments to prevent the acrylic resin escape around the neck of the equator during functional pick up procedure. The female stainless steel housing with the retentive caps were snapped on the equator abutment for functional pick up. The soft liner was removed from the fitting surface of the maxillary denture. Pressure indicating paste was used to identify the location of the attachment in the fitting surface of the maxillary denture. Relief was done in the fitting surface over the equator abutment and its metal housing. Small vents were made in the palatal surface to permit the escape of the excess auto-polymerized acrylic resin. The resin was mixed and placed in the relieved area of the fitting surface. Denture was inserted in patient mouth and patient was asked to bite in centric occlusion. After curing of the acrylic resin, the denture was removed; the excess of acrylic resin was removed, finished and polished. Occlusion was readjusted to ensure proper occlusal contact.
Evaluation of peri-implant tissue health for patients of each group was made for each study interval (six months) as follows; after two weeks of overdenture insertion (T0), three months (T1) and six months of overdenture insertion (T2) The parameters for peri-implant tissue health evaluation involve Clinical evaluation (modified plaque index, modified bleeding index and per-implant probing depth) and immunologically by measuring IL-1β levels in peri-implant sulcular fluid.

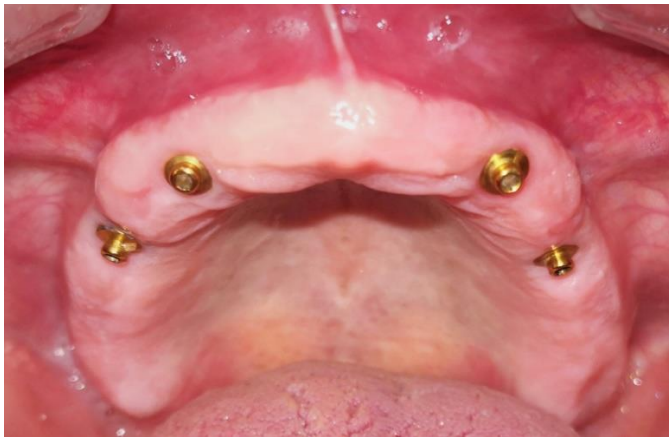

Fig (1): Maxillary four implants widely distributed at the canine and premolar areas bilaterally

Results

A. Plaque scores

Plaque scores significantly increased with advance of time for all groups except at canine implants in the 4-implant group. There was a significant difference between 2 implants canine and 2 implants premolar, and between 2 implants premolar and 4 implants canines. No significant difference between other groups was noted.

Table 1: Comparison of plaque scores between groups and between observation times.

		PI_T0	PI_T1		PI_T2	Freidman P value
2 implants (canine)	*M*	.00	.00		1.00	<.001*
	Min	.00	.00		1.00	
	Max	.00	1.00		2.00	
	Wilcoxon p value	.37				
				.011*		
			<.001*			
2 implants (premolars)	*M*	.00	1.00		2.00	<.001*
	Min	.00	.00		1.00	
	Max	.00	2.00		2.00	
	Wilcoxon p value	.050				
				.038*		
			<.001*			
4 implants (canine)	*M*	.00	.00		1.00	.181
	Min	.00	.00		.00	
	Max	.00	1.00		1.00	
	Wilcoxon p value	-				
				-		
			-			
4 implants (premolars)	*M*	.00	1.00		1.00	.009*
	Min	.00	.00		1.00	
	Max	.00	1.00		2.00	
	Wilcoxon p value	.29				
				.46		
			.006*			
Kruskal Wallis test P value		1.00		.10	.001*	

T0: 2 weeks after insertion, T1: 3 months after insertion, T6: 6 months after insertion, M: median, min: minimum, max: maximum, * P is significant at .05

B. Bleeding scores

Bleeding scores significantly increased with advance of time for all groups except at canine implants in the 4-implant group. There was a significant difference between 2 implants canine and 4 implants canines, and between 2 implants premolars and 4 implants canines. No significant difference between other groups was noted.

Table 2: Comparison of bleeding scores between groups and between observation times.

		BI_T0	BI_T1	BI_T2	Freidman P value
2 implants (canine)	***M***	.00	.00	1.00	<.001*
	Min	.00	.00	1.00	
	Max	.00	1.00	2.00	
	Wilcoxon p value	.27			
			.019*		
		<.001*			
2 implants (premolars)	***M***	.00	1.00	1.00	<.001*
	Min	.00	.00	1.00	
	Max	.00	1.00	2.00	
	Wilcoxon p value	.06			
			.001*		
		.049*			
4 implants (canine)	***M***	.00	.00	.00	.58
	Min	.00	.00	.00	
	Max	.00	1.00	1.00	
	Wilcoxon p value	-			
			-		
		-			
4 implants (premolars)	***M***	.00	.00	1.00	.004*
	Min	.00	.00	1.00	
	Max	.00	1.00	1.00	
	Wilcoxon p value	1.00			
			.038*		
		.005*			
Kruskal Wallis test P value		1.00	.35	.002*	

T0: 2 weeks after insertion, T1: 3 months after insertion, T6: 6 months after insertion, M: median, min: minimum, max: maximum, * P is significant at .05

. Probing depth

PD significantly increased with advance of time for group 2 implants canine only. There was no significant difference between groups at different observation times.

Table 3: Comparison of PD (in mm) between groups and between observation times.

		PD_T0	PD_T1	PD_T2	Freidman P value
2 implants (canine)	***M***	1.00	2.00	3.00	<.001*
	Min	1.00	1.00	2.00	
	Max	2.00	3.00	3.00	
	Wilcoxon p value	.80			
			.039*		
		<.001*			
2 implants (premolars)	***M***	2.00	2.00	2.50	.52
	Min	1.00	1.00	1.00	
	Max	3.00	3.00	4.00	
	Wilcoxon p value	-			
			-		
		-			
4 implants (canine)	***M***	1.00	2.00	2.00	.57
	Min	1.00	1.00	1.00	
	Max	3.00	3.00	3.00	
	Wilcoxon p value	-			
			-		
		-			
4 implants (premolars)	***M***	2.00	3.00	3.00	.86
	Min	1.00	1.00	1.00	
	Max	3.00	3.00	3.00	
	Wilcoxon p value	-			
			-		
		-			
Kruskal Wallis test P value		.31	,57	.35	

T0: at insertion, T1: 3 months after insertion, T6: 6 months after insertion, M: median, min: minimum, max: maximum, * P is significant at .05

D. Interleukin -1 β

IL-1β significantly increased with advance of time for all groups. For all groups, there was a significant difference between T0 and T2 only. No difference was noted between T0 and T1, and between T1 and T2. There was a significant difference between 4 implants canine and all other groups.

There was a significant difference between 2 implants canine and 4 implants canine and between 2 implants premolars and 4 implants canine. There was a significant difference between 2 implants canine and 4 implants canine and between 2 implants premolars and 4 implants canine.

Table 4: Comparison of Interleukin-1β between groups and between observation times.

		IL-1β _T0	IL-1β _T1		IL-1β _T2	Freidman P value
2 implants (canine)	*M*	150	199		250	.001*
	Min	148	193		216	
	Max	162	205		256	
	Wilcoxon p value	.16				
				.16		
			.001*			
2 implants (premolars)	*M*	150	218		250	.002*
	Min	131	205		241	
	Max	174	220		264	
	Wilcoxon p value	.23				
				.23		
			<.001*			
4 implants (canine)	*M*	120	154		198	.002*
	Min	115	136		179	
	Max	125	171		214	
	Wilcoxon p value	.21				
				.23		
			.001*			
4 implants (premolars)	*M*	145	190		220	.002*
	Min	140	164		203	
	Max	162	206		230	
	Wilcoxon p value	.19				
				.31		
			.002*			
Kruskal Wallis test P value	.	.011*		.001*	.003*	

T0: at insertion, T1: 3 months after insertion, T6: 6 months after insertion, M: median, min: minimum, max: maximum, * P is significant at .05

Discussion of results

It has been well established that implants develop peri-implant inflammations following osseointegration and loading that mimic those signs associated with periodontal disease.[10] Although the tissue appearance often reflect extensive inflammatory changes around dental implants, clinical and radiographic methods may not be a good clinical measure for monitoring early peri-implant health changes.[11] The initiation and early development of the lesion can be induced by bacterial metabolites, such as proteolytic enzymes, by cell surface molecules, like lipopolysaccharides, or by host cells that release several types of cytokines that can activate degradative pathways.[12,13]

Bleeding on probing as an indicator of the level of inflammation may be more directly related to the tightness of the mucosa around the abutment, and probing may result in tissue penetration, with subsequent bleeding occurring at otherwise healthy site.[11,14]

The objective detection of peri-implantitis during the early inflammatory phase could minimize the tissue damage and increase the potential for therapeutic success.[11,14] Common periodontal indices such as bleeding on probing and probing depth are not always a reliable tool for assessing peri-implant marginal soft- and hard-tissue conditions.[15] Thus, Interleukin-1β level has been established to be an important marker in PISF to evaluate the tissue destruction around dental implants.[16,17]

IL-1β is a strong pro-inflammatory protein that mediates the production of prostaglandins, leukotrienes in several cell types and promotes osteoclast formation and bone resorption.[10,13] Consequently, it is well-documented that higher levels of IL-1β have been associated with peri-implantitis.[10,18] Therefore, this cytokine is correlated with the early phases of the gingival inflammatory process and may be used to monitor disease progression.[13]

Regarding the implant numbers and their distribution they showed significant differences in PI, BI, PD, and IL-1β values between 2-weeks and 6 months from prosthesis

insertion. These findings may be related to the improved oral hygiene and maintenance of the patients over time.[13,19]
In this study, there was significant difference in the plaque index along the different time periods in all groups except 2 canines in 4 implant group. This may be due to the distally inclined premolars implant which allows accumulation of food particles and plaque in the distal area which also may

considered inaccessible for proper cleansing by the patient.[20]This observation was supported by the statistically significant difference between 2 canines group and 2 premolars group at 6 month observation; this may be due to the difficulty for the patients to clean the peri-abutment zone of the posterior region.
There was significant difference in the bleeding index along the different time points in all groups except 2 canines in 4 implant group. This finding agreed with **Kurtzman** et al.,[21] who explained that microbial plaque accumulation is associated with increased mucosal inflammation and increased bleeding on probing.
Initial biochemical analysis of IL-1β level for 2-canines and 2-premolars locations revealed range values of 148-162 pg/µl and 131-174 pg/µl, respectively. **Panagakos and coworkers.,**[14] also observed greater levels of inflammatory cytokines in PICF around early and advanced peri-implantitis groups as compared to the healthy group.[22] However, The reversibility of IL-1β levels agreed with experimental peri-implant mucositis study conducted by Salvi et al.,[23]
Initial biochemical analysis of IL-1β level for canine as related to premolar locations in 4-implant locations revealed range values of 115-125 pg/µl and 140-162 pg/µl, respectively. At the 6th month, values of IL-1β in peri-implant mucosa were well within the range of healthy implants as seen by previous studies. [10, 11,18]
In comparison to clinical parameters, there were no significant differences between the 3rd month and 6th month IL-1β level in PISF. This may be related to the residual scaring from the surgical procedures of implant placement surgeries that may complicate the reliability of the peri-implant assessment.[16]
Lower values were noticed at the canine areas favoring 4-implants over 2-implants for retaining the overdenture. These findings can be attributed to the effect of occlusal loading of the prosthesis, thus, a widely distributed load on more implants could increase the success rate and minimize the peri-implant tissue destruction.[10,24] Therefore, the study revealed a significant increase in clinical parameters and IL-1β with 2-implants in premolar areas in comparison to 2-implants in the canine areas. These findings concurs with the concept of using removable implant-retained prostheses stabilized on implants only in the frontal area of edentulous jaws to replace posterior teeth in the maxilla.[25]
Regarding the overdenture design, the surprising results were found in 2-implants in the canine areas alone when compared to the 2-implants combined with 2-implants in premolar areas. The insignificant measurements in all parameters after 6th month period disagree with a recent systematic review by **Kern et al.,**[26] who reported that implant loss for maxillary overdentures supported by less than 4 implants was significantly higher than that for those supported by 4 implants.
This controversy may be explained by using palatal support through the denture base may distribute the occlusal load per unit area and reduce the functional load on the 2-impants axially located in the canine areas.[27,28] The significant bleeding scores noticed at 6th month may be attributed to the wear of nylon inserts that may cause peri-implant mucosal

injury. Maintenance of implant retained prostheses and replacement of attachment inserts are required routinely.[27]
The insignificant values that were measured for 2 implants in premolars location in comparison to 4-implants may be attributed to the inclined position of these implants that may increase the load applied in an off-axis manner.[24] Moreover, Equator attachment may not provide sufficient splinting for the implants through the denture base to compensate the splinting bar postulated by **Malo et al.,**[8] Moreover, plaque accumulation around dental implants can result in the development of an inflammatory reaction in the peri-implant mucosa especially for tilted implant.[13] In the presence of overload, the microbial plaque can alter the host response to inflammation increasing the release of IL-1β and IL-6 mainly.[29] Despite absence of rigid splinting between the implants, the placement of posterior implants based on All-on-4 concept with resilient attachment may be more suitable with conventional loading protocols.[24,30]
In this short term study, all the implants were in function and accepted as being clinically satisfactory. Therefore, we need to take care when interpreting the present results. This study has some limitations including; small sample size, short-term study with short follow-up periods, and lack of radiographic parameters. Clinical and biochemical parameters are not always indicative of implant failure because peri-implantitis is defined as an inflammatory process around an osseointegrated implant in function and results in supporting bone loss.[18,31] Cytokines are not routinely measured to monitor peri-implant health because their baseline levels are unknown.[32] The study ignored the association between signs of peri-implant inflammation and increased levels of inflammatory mediators in the PISF.

Conclusion

Within the limitation of this study regarding the small sample size and short study periods, it is possible to conclude that: the clinical tissue changes and biochemical parameters revealed a biologically accepted peri-implant health around either two or four implants retaining the maxillary overdenture. The use of unsplinted attachments to retain maxillary overdenture favors the use of four implants over two implants either in the canine or premolar areas.

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