THE EFFECT OF ANTERIOR-POSTERIOR SPREAD AND CANTILEVER LENGTH ON THE SUPPORTING STRUCTURES OF MAXILLARY SCREW RETAINED PROSTHESIS

Heba E. Khorshid * *and* Nora M. Sheta*

ABSTRACT

Purpose: The Target of this work was to study the effect of three different ratios of anterior-posterior spread to the cantilever length on the supporting structures of implant- screw retained maxillary prosthesis ;

Materials and Methods: In this study, maxillary implant screw retained prostheses were placed in fifteen completely edentulous patients. Each patient received six implants in the maxilla. Patients were divided into three equal groups; Group I, II & III according to the ratio of anterior-posterior implant spread to the cantilevers lengths (CL/ AP). The / CL AP ratio was 1:1, 1:2 and 1:3 in the three groups respectively. In this Study, crestal bone height changes around each implant were evaluated at time of prostheses insertion, four, eight and twenty-four months later using CBCT.

Results: The results of this study revealed that the least bone height loss was noticed in Group III. Statistically significant difference was reported between Groups I, II& III in bone height loss.

Conclusion: Within the limitation of this study, it might be concluded that the cantilever extension to antero-posterior implant spread with 1:3 ratio might have induced the least crestal bone height loss around each implant in maxillary screw retained prostheses.

KEYWORDS: edentulous maxillae, screw retained restorations, anterio-posterior spread , cantilever length

INTRODUCTION

The rehabilitation of partial and completely edentulous cases can be achieved with the use of screw-retained implant prosthesis [1]. Misch[2] summarized the advantages of screw retained prosthesis into that they are easy and safe to use, no cement in soft tissue peri-implant area, retrievability, excellent retention even for small diameters and can be used in cases with limited inter-arch distance. The minimum numbers of dental

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* Lecturer, Department of Prosthodontics, Faculty of Oral and Dental Medicine, Cairo University.

implants can be used to support screw retained prostheses varies from 4 to 6 implants according to the original Branemark protocol [3]. The anatomical structure of edentulous maxilla is different from that of mandible as the presence of soft trabecular bone, the maxillary sinus and nasal cavity which can complicate implant placement and prosthetic treatment [4, 5]. The problems of poor bone quality, inadequate bone height in the posterior maxillary region and non-parallel implants can be solved with the use of screw retained implant supported cantilevered prostheses [6]. Screw retained full arch prostheses usually need a cantilever extension of the prosthetic structure bilaterally from the most posterior implant. The clinical advantages of this cantilever extension include shorter treatment time, lower cost, and the fact that it does not require complex reconstructive surgeries. [7,8]

Cantilever length (CL) is understood as the fraction of superstructure projecting beyond the most distal implant, while antero-posterior (AP) spread refers to the distance between the line connecting the two most distal implants (at their distal edge) and the center of the most distant implant, thus providing a rough measure of geometric implant distribution. [2] The ratio between the two CL and AP represents a measure of the amount and distribution of the occlusal load [8]. The AP spread then can be multiplied by one and a half to two and half times to give a guideline of how long a distal cantilever could be acceptable [9]. Other factors have to be taken in to account such as the Patient age, gender and opposing dentition in the decision making process of how long a cantilever is acceptable for the specific patient situation.[9]

Rangert [10] provided simple guidelines for controlling occlusal loads on implants and prosthetic reconstruction; an A-P-spread of at least 10 mm was proposed for a cantilever of 20 mm for mandibular implant supported prosthesis. English [11] proposed that a very reasonable rule of thumb for determining posterior cantilever in mandibular implant supported prosthesis should be 1.5 times the A-P-spread (around 10-12 mm posterior cantilever for the mandible), whereas maxillary posterior cantilever should be reduced to 6-8mm due low bone density.

Axial and bending forces are the two main types of forces directed on the cantilevered prosthesis[12]. The greater the cantilever length, the greater is the Class I lever arm and bending moment on the implants supporting the prosthesis and hence the greater the risk of implant and prosthetic complications and Failures. [12]

Therefore, the most crucial factor in the success or failure of the implant supported prosthesis is the ratio of cantilever length to the AP spread.[13] The longer cantilevers resulted in higher stress at implant sites, thus eliciting more marginal bone loss around implants.[14] Nonetheless, studies showed similar success rates for implants either with or without cantilever extensions.[15,16] Meanwhile, the effect of cantilever extensions upon marginal bone loss and prosthetic/biologic complications still remains vague and requires further analysis and studies. [16]

The Target of this work was to study the effect of three different ratios of anterior-posterior spread to the cantilever length on the supporting structures of implant- screw retained maxillary prosthesis ;

MATERIALS AND METHODS

Fifteen male patients were selected from the outpatient clinic of the Prosthodontics Department, Faculty of Oral and Dental Medicine, Cairo University. Patients were with Completely Edentulous Maxillae showing normal maxillo-mandibular relationship (Class I Angle classification), with no para-functional habits and systemically free from any medical conditions.

In this study, patients were divided into three equal groups (five patients in each group): Group

I: Patients receiving screw retained prosthesis with a ratio of 1:1 cantilever length to Antero-Posterior spread; Group II: Patients receiving screw retained prosthesis with a ratio of 1:2 cantilever length to Antero-Posterior spread and Group III: Patients receiving screw retained prosthesis with a ratio of 1:3 cantilever length to Antero-Posterior spread. The patients were categorized into each group according to their bone height and width availability, arch morphology as well as their maxillo-mandibular relationship and the proposed occlusion.

Construction of conventional maxillary complete dentures was first performed which were then duplicated to obtain radio-opaque scan appliances. The patients' maxillae were radiographed using Cone Beam Computed Tomographic (CBCT) scanning machine (**Scanora 3D Soredex, Helsinki, Finland**). The patients were trained to wear their stents and to stabilize it in place by biting on an occlusal index constructed for each patient, separating the mandibular teeth from the stent during the imaging procedure. DICOM files obtained from the CT scan were loaded into the Mimics software whereby coronal and sagittal reformatting and panoramic views were obtained. The chosen implant sites were acknowledged through the radiolucent channels previously prepared in the radiographic stent at the prosthetic teeth centers. The bone volumes at each of the six potential sites were assessed for sufficient bone height, width and density. For each patient, six implants were to be planned in the lateral incisor/ Canine region, first premolar and first molar region according to the available bone height and width. All Implants were with standardized height; 13 mm for the four anterior implants and 10 mm for the two posterior implants *(Figure 1)*. The Patients were categorized into each group according to their available bone height. The virtual STL files of the implants were imported into the MIMICS software and then virtual planning at the proposed implant sites, thresholding and segmentation was performed to obtain the 3D virtual stent. The 3D virtual stent was then exported as an STL (Sterolithiographic) file for 3D printing machine (**Invision Si2, USA**) to build the stent from a photo curable resin material. Metallic sleeves were fitted into the designed holes of the fabricated stent and then the stent was tried in the patient's mouth to check stability and fit.
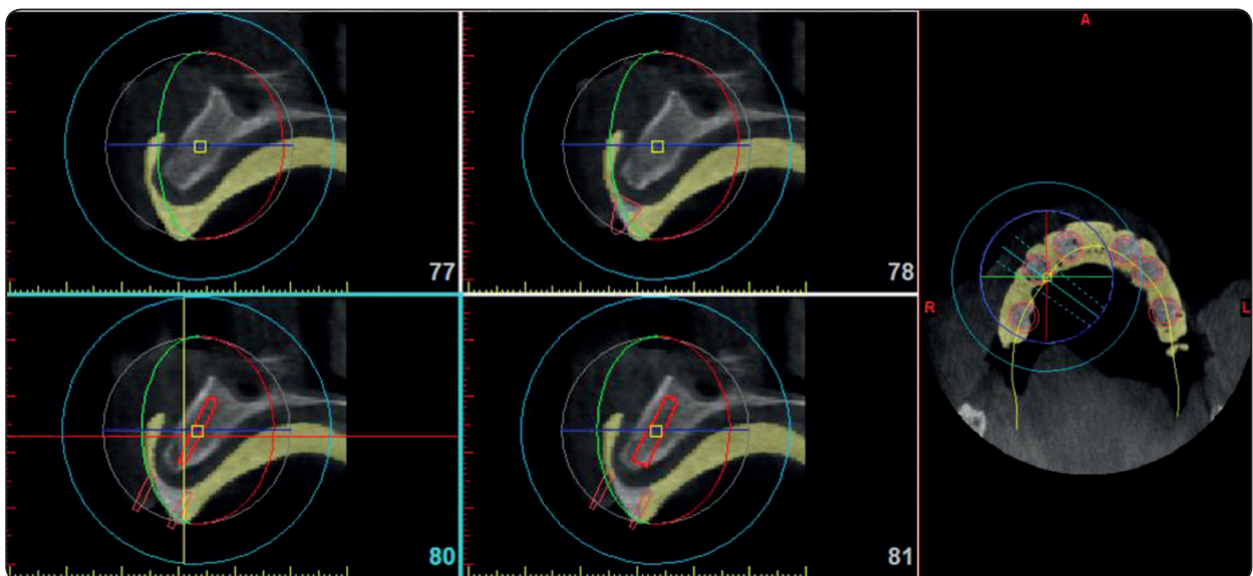

Fig. (1) Implants being planned at each potential implant site

Implant installation

Before starting the surgical procedure, the computer guided stent and peri-oral region of the patient were disinfected with a suitable disinfectant. At the time of surgery, infiltration anaesthesia was injected at each implant site. The stent was fixed in place using three fixation screws. Osteotomies were then prepared using a specially designed "drill guide" and the classical drilling sequence (pilot, intermediate and final drills) and were irrigated with sterile saline after each drill. The implants were then unpacked and inserted manually through the stent till manual tightening met resistance and further tightening was completed with a ratchet using a depth controlling implant driver *(Figure 2)*. The primary stability of each implant was checked using "Osstell"[*] ISQ device.
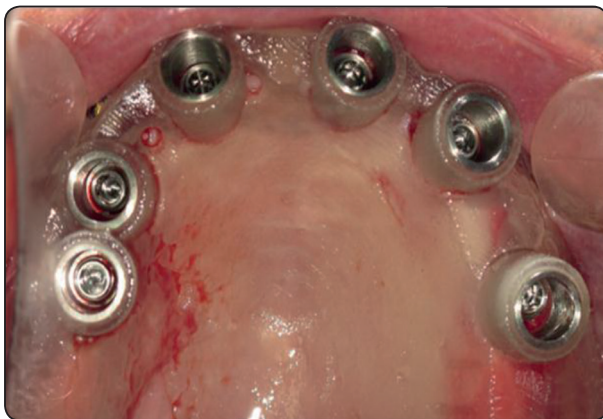

Fig. (2) Surgical Placement of implants before surgical stents retrieval

After 4-6 months, the patients were recalled and the Implants were checked for adequate osseointegration. The snap-on Implant plastic transfer copings supplied with the implants were placed over each implant and preliminary impression were then taken using a closed tray technique with medium body rubber base impression material. The implant analogues[**] were then snapped on over the Plastic transfer copings inside the impression and then the impression was poured using medium hard stone.

Temporary Titanium abutments were then screwed over the implant analogues within the primary cast and then splinted together using DuraLay resin material[***]. The framework was then tried in the patient's mouth and screwed over the implants. The passive fit was checked using the one screw test and using an intraoral explorer.

Bite registration was then performed using the Wax wafer registration method. Acrylic teeth were set on the framework following the IPO Misch guidelines. Visio-lign Veneering (Visio-lign, Bredent GmbH & Co.KG, WeissenhornerSenden, Germany) light cured system was used to construct the gingiva using a free-hand technique In this study, each patient's anterior- posterior AP spread to the cantilever ratio was measured using a ruler on the patient's cast. *(Figure 3)*. The lengths of the cantilevered segments of the definitive prostheses were measured with a Boley gauge after all finishing and polishing procedures were accomplished, just
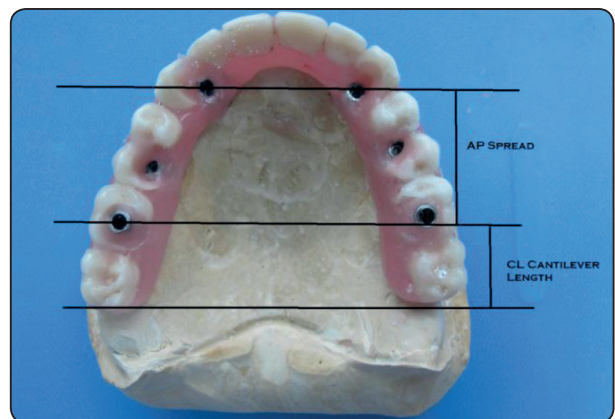

Fig. (3) Restoration fabricated on the cast

prior to insertion. The length of the cantilever segments were fabricated for each case according to the group that they were sorted in from the beginning and according to the AP spread measurement that he recorded. Each patient was categorized into his specific group according to their bone height and width availability, arch morphology as well as their maxillo-mandibular relationship and proposed occlusion. The measurements were made from the distal surface of the most distal implants on both sides to the distal surfaces of the interim prosthesis on both sides. The AP spread was measured on the master casts by laying two straight rulers across the screw access openings of the anterior and posterior abutment analogs; right anterior abutment analog to left anterior abutment analog for the anterior line; right posterior abutment analog to the left posterior abutment analog for the posterior line. The distance between these two straight anterior and posterior lines was measured using a mm ruler to obtain the AP Spread.

After the build-up is complete, the screw-retained implant supported prostheses were screwed intra-orally and fine occlusal adjustments were made in both groups *(Figure 4).* The prosthetic screws were tightened to 30Ncm with a torque wrench. The access holes were partially plugged with rubber
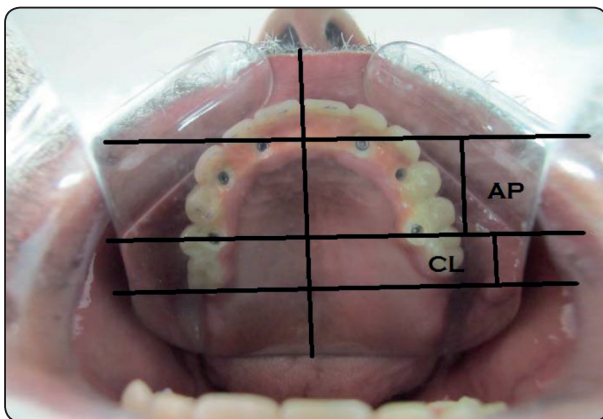

Fig. (4) Restoration Delivery

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* Scanora 3D Soredex, Helsinki, Finland

pieces and completely blocked with light-cured composite resin restorative material.

In this study, each patient performed three follow-up CT scans using CBCT machine.[*] The CT scans were performed at zero, four, eight and twenty four months after definitive prostheses delivery to record bone height changes around each implant. The numbers obtained were then tabulated and statistically analyzed.

Statistical analyses

The results of this work were statistically analysed to evaluate differences in marginal bone change between the three groups around each implant (bucco-palatal and mesio-distal bone). Mean values and standard deviation (SD) were calculated for each variable at time of prostheses insertion, four, eight and twenty-four months later.

Statistical Methods

The normal distribution of parameters was tested by Shapiro-Wik test .Normally distributed continuous variable were tested using unpaired T student test or Anova. Probability values ≤0.05.all calculations were made with the DPSS software package (version 13.1: SPSS Inc)

RESULT

A total of 90 implants were placed in fifteen patient over which screw retained implant supported maxillary prosthesis were fabricated. Each patient received six implants which were nominated from 1 to 6 starting from the right hand side to the left hand side of each patient. The patients were divided into three groups according to CL/AP ratio. The recorded mean differences and standard deviation of the peri-implant marginal bone height loss in the three groups at different follow up period was shown in table 1.

TABLE (1) The recorded mean differences and standard deviation (S.D) of the crestal bone height loss of implants in the three groups at different follow up period

Interval	Group I		Group II		Group III		*P-value*
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	
From loading-4 m	-1.19	0.34	-0.87	0.20	-0.25	0.14	0.00
4m-8m	-0.33	0.20	-0.22	0.09	-0.24	0.29	0.45
8m-24m	-0.09	0.04	-0.23	0.11	-0.05	0.02	0.00
From loading-24 m	-1.61	0.42	-1.33	0.24	-0.56	0.37	0.00

p≤0.05

As shown in table 1, results revealed statistically significance difference between the three groups at all the different follow up periods (p-value=0.00). Group III showed least mean bone height loss throughout the whole study period except from four to eight months follow up where there is no statistically significance difference between the three groups.

Statistical comparisons between Group I and Group II showed no significant difference p-value= 0.498 and 0,167 at the follow period up from four months to eight month and from time of loading to twenty four months respectively. The results also showed statistical significant difference p-value=0.039 and 0.004 at the follow period up from time of loading to four months and eight month to twenty four months respectively. The recorded mean differences and standard deviation (S.D) of the bucco-palatal and mesio-distal bone height for each implant in the three groups from the time of prostheses placement to four months are shown in table 2**.**

Group III recorded the least mean bone loss of the all implants regarding both their positions and the mesiodistal (MD) or bucco-palatal (BP) bone from the time of prosthesis placement to four months as shown in **table 2**. The MD and BP bone of Implant 4 showed statistically significance difference with P-value =0,021and 0.014 respectively. The BP bone of implant 5 showed statically significance difference with P–value =0.00. All the remaining implant showed no statically significance difference neither in BP nor MD bone.

As shown in figure 5, the mean difference of the bucco-palatal and mesio-distal bone of all the implants in group III showed the least bone height loss with statistically significance difference at MD and BP bone of implant 2 and BP bone of implant 3 with p-value= 0.05 between the three groups. The MD and BP bone of implant 4 showed statistically significance difference between the three groups with P-value=0.01and 0.02 respectively. The MD bone of implant 5 also showed statistically significance difference between the three groups with P-value<0.001.

TABLE (2) The recorded mean differences and standard deviation (St.D) of the bucco-palatal and mesio-distal of the crestal bone height loss for each implant in the three groups from the time of prosthesis placement to four months.

From time of loading –four months	Group I		Group II		Group III		
Implant	Mean	SD	Mean	SD	Mean	SD	P- value
IMP 1MD	-0.94	0.63	-0.98	0.56	-0.22	0.32	0.072
IMP1 BP	-0.60	0.53	-0.78	0.57	-0.20	0.36	0.217
IMP2 MD	-1.06	0.58	-0.88	0.58	-0.23	0.83	0.168
IMP2 BP	-1.16	0.59	-0.62	0.73	-0.24	0.24	0.069
IMP3 MD	-1.45	1.10	-1.00	0.88	-0.37	0.40	0.174
IMP3 BP	-0.95	0.62	-0.75	0.69	-0.25	0.28	0.175
IMP4 MD	-1.46	0.74	-0.55	0.87	-0.08	0.23	0.021
IMP 4BP	-1.89	0.90	-1.13	1.00	-0.15	0.15	0.014
IMP5 MD	-1.37	0.24	-0.72	0.54	-0.07	0.16	0.000
IMP5 BP	-0.88	0.86	-1.01	0.76	-0.29	0.28	0.251
IMP6 MD	-1.43	1.32	-1.25	0.756	-0.61	0.55	0.378
IMP6 BP	-1.11	1.07	-0.79	0.59	-0.40	0.36	0.347

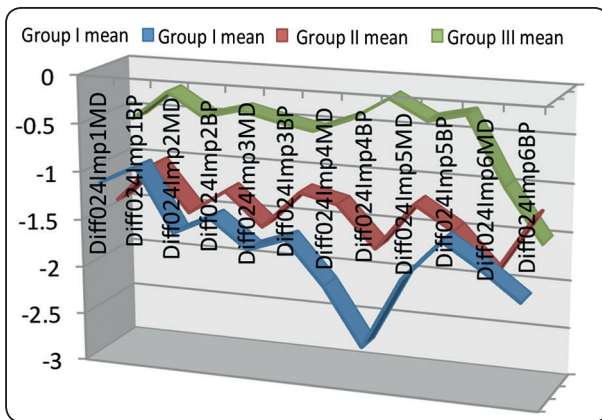*p<0.05   MD=mesiodistal   BP= Buccopalatal*

Fig. (5) The mean difference of the bucco-palatal and mesio-distal bone height change of implants from the time of prosthesis placement to the end of follow up period (24 months)

DISCUSSION

Within the limitation of this work, all implants included were considered successful in the three groups with different CL/AP ratios according to the ICOI (International Congress of Oral Implantologists) Pisa Consensus Conference March 2008. [17] In this work, three groups with different CL/AP ratio were chosen according to the recommendation of Prucell et al. [18] who preferred dividing them into three groups; from 1 to 1.5, from 1.5 to 2.0, and greater than 2.0. Six implants were placed in each maxilla to ensure a sufficient number to retain maxillary prostheses with larger cantilever lengths. The most distal implant was also placed in the molar region. This was in agreement with a study performed by McAlarney and Stavropoulos [9] who stated that the increase number of implants also played a role in the ability to cantilever as this

provides better implant force distribution. They also stated that the position of the most distal implant is an important clinical factor as distal implants placed in the first molar sites is more often clinically preferable than it to be placed in a more anterior position. The more distal the most posterior implant, and the more mesial the most anterior implant, the higher the AP spread and hence the more permissible it is to do more Cantilever Lengths. In this study, a millimetre ruler and a boley gauge was used to measure the A/P spreads and CLs following the same technique used in a study performed by Drago. [19] The millimetre ruler was likely to be accurate to 0.5 mm and the boley gauge was accurate to 0.1mm which was considered another limitation within this study.

Statistical analysis of the mean values of the bone height changes in the three group revealed that the longer the AP to the cantilevers length as in group III, the lesser the amount of peri-implant bone loss. In fact, a statistically significance difference in the mean bone height values was revealed between the three groups throughout the whole study period except for the period from four month to eight month. This might have occurred due to the stabilization of the bone remodelling process around the implants and improvement of the biomechanical situation as agreed upon by Enlow [20] and Sleats et al. [21] The results also revealed that when comparing bone loss in Group II and Group I, there was no statistical difference between these two groups at the follow period up from four months to eight month and from time of loading to twenty four months. The statistical analysis of bone loss in group I (1:1) CL /AP/ also showed the greatest amount of bone loss throughout out the whole study follow up period. This was in accordance with a study performed by Hurley et al. [22] who claimed that the implant forces are lower with a greater AP spread value since it provides better tripodization and a more favourable implant distribution. Hence it can be concluded that the amount of AP spread can indicate the ability to do distal cantilevers.

The results of this study are basically in agreement with the results reported by McAlarney and Stavropoulos [9] who concluded that the implant distributions with high CL provided adequate occlusion however implicated an increase in the prosthetic complications of full-arch prostheses. McAlarney and Stavropoulos [23] also noted that prosthetic complication rates could be decreased if CLs were less than those calculated from linear equations, and if AP spreads were greater than 11.1 mm. Although there was a trend of increasing CL with increasing AP, a single CL to AP ratio for all distributions cannot be indicated. Naert et al.[24] also concluded that for three years, the length of the cantilever had a significant impact on the amount of marginal bone loss around implant. Although mesial cantilever prostheses have been perceived to be more favourable than distal cantilever prostheses, a study about the difference of stress distribution between mesial cantilever prostheses and distal cantilever prostheses is demanded. [25]

In the current study, results also highlighted more bone loss in Implants 4 especially in group I. This can be explained by the fact that implants placed at the premolar region at the corner of the arch received fairly higher forces due to the mesial rotation of the restoration under functional masticatory forces. This was in accordance with a finite element study performed by Park et al. [26] who also found that in the models with a mesial cantilever, first premolar tooth supported a portion of stress which may have resulted from the mesial rotation of the prostheses. The added factor of the presence of a horizontal cantilever in this region might have added more load on these implants as explained by Misch. [25] Prucell et al. [18] and Takayama [26] also added that AP spread is hard to be an isolated factor and that there are a number of variables related to mechanical complications which include implant occlusion, the antagonistic arch, vertical dimension and/or prosthesis height/implant ratio, patient occlusal force, and para-functional habits.

CONCLUSION

With all the limitations of this work, it can be generally concluded that the high mean bone height loss in Group I throughout the whole period of this study was due to the long cantilever length compared to the AP spread which lead to unfavourable force distribution and load on the implants. The cantilever extension to antero-posterior implant spread to with 1:3 ratio might have induced the least crestal bone height loss around each implant in maxillary screw retained prostheses.

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