IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 18, Issue 12 Ser.11 (December. 2019), PP 38-51
www.iosrjournals.org

Rehabilitation of edentulous maxilla complicated with combination syndrome with All On Four® Implant supported fixed prosthesis (Clinical and Radiographic Evaluation of peri-implant tissues)

AbeerAlawadhiBDS[1], Ahmed Habib, MSc, PhD[2], Mohamed ElgamalBDS, MSc, PhD[3]

[1] *B.D.S.faculty of dentistry (2009), 6th october University, Egypt.*
[2.] *Professor of removable prosthodontics, faculty of dentistry, MansouraUniversity*
[3.] *Lecturer of removable prosthodontics, faculty of dentistry, Mansoura University.*

Abstract
Purpose: *The aim of this study was the clinical and radiographic evaluation of maxillary implants after rehabilitation of edentulous maxilla complicated with combination syndrome with All On Four® Implant supported fixed prosthesis*
Materials and methods:
Twelve patients with total edentulous maxillary ridgesand partially edentulous mandibular ridges (class I Kennedy classification) received maxillary fixed prosthesis supported on four implants placed according to All On Four® concept and mandibular distal extension RPD. Clinical evaluation of maxillary implants was made at in term of plaque index, gingival index, pocket depth and implant stability at time of prosthesis insertion (T0), 6 months (T1) and 12 months later (T2) while radiographic evaluation at T1 and T2 were performed in terms of peri-implant alveolar bone lossusing standardized periapical radiographs for anterior and posterior implants.
Results:*Clinical evaluation showed that plaque scores, pocket depth significantly increased with advance of time for anterior implants and posterior implants.No significant difference in gingival scores between observation times was noted for anterior implants and posterior implants. No significant difference of plaque scores, gingival score, pocket depth and implant stability between anterior and posterior implants was noted at all observation times. (P>.005). For radiographic evaluation vertical bone loss significantly increased at T12 compared to T6 for anterior implants and posterior implants. However vertical bone loss for anterior implants was significantly higher than posterior implants at T6 and T12. (P<.001).*
Conclusion
Within the limits of this study regarding the small patient sample and the short follow up time frame, it could be concluded that; All On Four® Implant supported fixed prosthesis for rehabilitation of edentulous maxilla complicated with combination syndrome was associated with favorable clinical and radiographic peri-implant tissues responses after one year. However, it should be noted that anterior implants were at higher risk of increased peri-implant bone loss compared to posterior implants

Date of Submission: 17-12-2019 Date of Acceptance: 31-12-2019

I. Introduction

Combination syndrome was first described by Kelly[1] as destructive changes in hard and soft tissues of patients with complete maxillary denture opposing an unstable bilateral free-end mandibular partial denture. The long-term result is extrusion of the remaining mandibular anterior teeth and the alveolar process surrounding them with loss of posterior mandibular bone. The plane of occlusion becomes reversed. Papillary hyperplasia of the hard palate develops. The premaxilla becomes atrophic as a result of the force exerted on this soft bone during occlusion. The maxillary tuberosity develops hypertrophy, creating a limited interarch space[2].

Placement of osseointegrated implants with attachments in the anterior maxillary ridge will also improve the stability and long-term prognosis of the prosthesis. As with overdenture abutments, osseointegrated implants in the maxillary anterior region will help support a maxillary prosthesis and resist harmful forces to the bone[3].

The technique for total rehabilitation of the edentulous patient or for patients with badly broken down teeth, decayed teeth or compromised teeth due to gum disease, known as the All-on-4 treatment concept, is a prosthodontics procedure was developed, institutionalized and systematically analyzed in the 1990s through studies funded by Nobel Biocare in collaboration with a Portuguese dentist Paulo Maló. It consists of the

rehabilitation of the edentulous maxilla and mandible with fixed prosthesis by placing four implants in the anterior maxilla and mandible, where bone density is higher. The four implants support a fixed prosthesis with 12 to 14 teeth and it is placed immediately on the day of surgery. The back implants are typically angled approximately 30 to 45 degrees from the biting plane. The implant is placed in front of the maxillary sinus in the upper jaw (maxilla). The head of the implant emerges in approximately the second premolar position. This will allow a molar tooth to be cantilevered posterior resulting in a denture or bridge with approximately 12 teeth.

According to Krekmanov et al[4], posterior tilting of distal implants will reduce cantilever lengths, increase anterior posterior spread, broaden the prosthetic base and improve implant to bone surface areas because longer implants can be used. The All-on-4treatment concept has several advantages that allow maximal use of the available bone to avoid invasive bone grafting procedures, resulting in significantly less morbidity, minimization of micromovement to achieve osseointegration steadily, placement of acrylic interim prostheses on the day of surgery for immediate loading of implants and maintaining oral functions; and dramatically lower financial costs and less time-consuming treatment

The aim of this study was the clinical and radiographic evaluation of maxillary implants after rehabilitation of edentulous maxilla complicated with combination syndrome with All On Four® Implant supported fixed prosthesis**.**Clinical and radiographic parameter will be evaluated at time of fixed prosthesis insertion (T0), 6 months after insertion (T6) and 12 months after insertion (T12).

II. Materials and Methods

I. Patient selection:

Twelve patients with total edentulous maxillary ridges and partially edentulous mandibular ridges (class I Kennedy classification) and age ranged from 56 to 66 years, were selected from outpatient clinic of the prosthodontic department, faculty of dentistry, Mansoura University for this study according to the following criteria:All patient had edentulous maxilla and had mandibular anterior teeth only remaining, All patients were either unsatisfied by the retention and stability of maxillary conventional denture and presented clear preference for a stable prosthesis or need a fixed prothesis in the upper jaw, all patients were healthy, free from any systemic diseases relating to bone resorption such as uncontrolled diabetics or osteoporosis. This was achieved through medical history and clinical examination by physician, sufficient bone quantity and quality in the area anterior to maxillary sinus of the maxilla verified by preoperative CBCT which allow receiving implants of at least 3.8 mm diameter and 11 mm length.Sufficient restorative space must be to permit construction of the fixed prosthesis (class I and II according to Ahuja and Cagna).[5] This was detected by a tentative jaw relation.and Participants with diabetes mellitus, osteoporosis, immune deficiency, anticoagulant therapy, radiotherapy to the head and neck region, and smoking habits were excluded.

II. Study design

- The patient cohort was composed of 12 patients with total edentulous maxillary ridges and partially edentulous mandibular ridges (class I Kennedy classification) who are going to receive maxillary fixed screw retained prothesis and distal extension mandibular partial dentures. After the patients were informed about the line of treatment and the need for regular and frequent recalls, they all signed a written consent. The study was conducted according to the ethical principles stated and approved by the ethical committee of the faculty of dentistry with no (01020418).

III. Pre-surgical prosthetic procedures:

For all participants, the following procedures were done:

Preoperative CBCT**(**i-CAT next generation CBCT machine; (Imaging Sciences International ISI, Pennsylvania, USA)was made to evaluate quantity and quality of remaining bone and the relation to vital structures (maxillary sinuses).Based on the CT scan, every patient's surgery was virtually planned with the OnDemand 3D software. The four implants virtually placed using the accompanying software, which optimize position, distribution and angulation of the implants.

For all patients, new conventional maxillary dentures and mandibular distal extension RPD were fabricated to restore optimal OVD, mandibular position, and occlusal planes.

- Guttaperchae radiopaque markers were fitted to the fitting surface of maxillary denture (at midline, ridge lap area of lateral incisor, canine and teeth) to be used asradiographic guide. Patients underwent panoramic x-ray to accurately assess the point of fixation of the surgical template and the relation to maxillary sinuses.

- Participants were premedicated with mouth wash: chlorhexidine digluconate 0.2% Started 3 days before surgery, immediately before the procedure rinsing or swabbing the mouth for 1 to 2 minutes, then daily for 7 days following the surgical procedure and antibiotics: amoxicillin and clavulanic acid (Augmentin® 1gm) were taken at 8 hours and 1 hour before the surgery and for 10 days following the procedure.

IV. Surgical procedures:

1) Implant installation

-Infiltration anaesthesia(Mepecaine-L: 2% Mepivacainehydrochloride- Levonordefrin (1:20,000) were performedbuccal and palatal to implant sites.

- One stage surgical implant protocol with flap reflection was used to install the four Implants used in this study in the intermaxillary sinus area of the maxilla.
- When necessary, bone shaping was performed to level the bone crest.
- Implant placement was assisted by a specially designed surgical guide (WINSIX Just Guide; Biosafin, Ancona, Italy)that facilitated correct implant tilting and precise positioning of the implants in relation to the opposing jaw and new tooth positions (fig1).
- Implant insertion (Biohorizon, Irvine, California, USA) was made according to the All on four protocol[6]. Two implants were designed to be at canine/lateral incisor area perpendicular to occlusal plane and paralleling to each other, while the posterior ones were designed to be at premolar area just anterior to maxillary sinus, take into consideration the safety margin. The posterior implants were tilted distally forming a 30-degree angle from the vertical plane and implants were emerged in the mesial region of the first molar tooth.

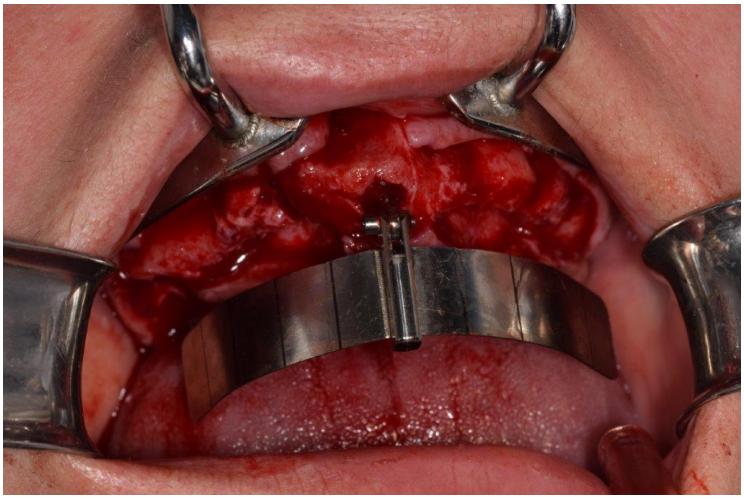

Fig 1. The metal surgical guide for All On four implant placement

- Implant insertion was completed using hand ratchet at torque of minimum 40 Ncm. Bicortical anchorage was established whenever possible.
- 17^{o} multiunit abutments were screwed in the anterior implants (fig 2) and 32-degree multiunit abutment were screwed into posterior ones (fig 3), all abutments were screwed at torque 25 Ncm.

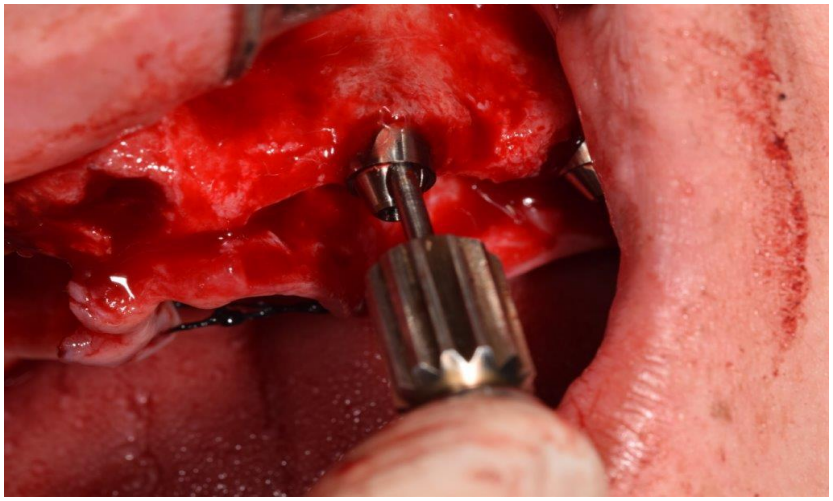

Fig 2. Screwing of 17^{o} multiunit abutments

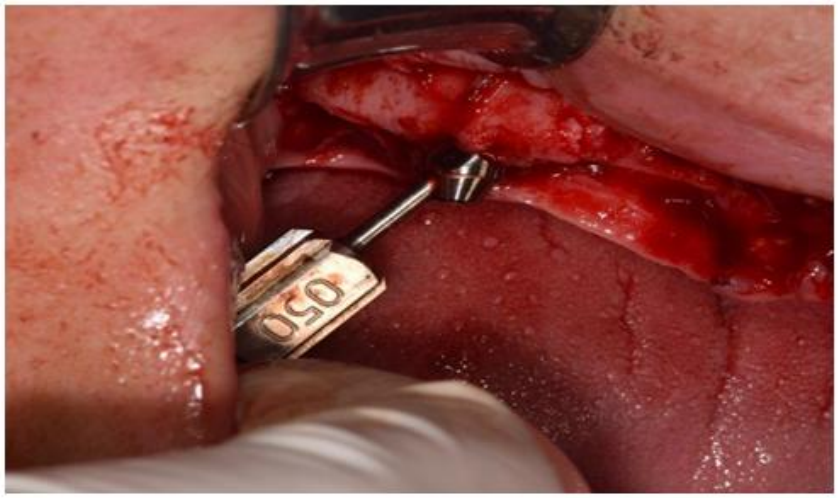

Fig 3. Screwing of 32^{o} multiunit abutments

2) Immediate loading of implants

- Healing caps were screwed to the multiunit abutments
- The flap was closed using interrupted sutures (Vicryl; Ethicon, Johnson & Johnson, New Brunswick, NJ) Temporary abutment metal caps were screwed to the multiunit abutment.
- The old denture was modified by removing the flanges, and the palatal portion of denture and the second molar artificial teeth, and the denture base opposite to the multiunit abutments was hollowed with the help of bite registration paste
- Rubber dam sheet perforated around the abutments and applied to avoid the acrylic resin flow to peri-implant gingival margin, also utility wax used to block out any abutment undercut (fig 4).
- Auto polymerized acrylic resin was used to pick up the temporary metal abutment caps to the modified denture. The metal caps was unscrewed, removing the denture, excess acrylic resin was removed and the denture finished and polished and temporary denture was screwed to the multiunit abutment to immediately load the implants (Fig. 5).
- The centric and lateral contacts was limited at inter canine area.[7]

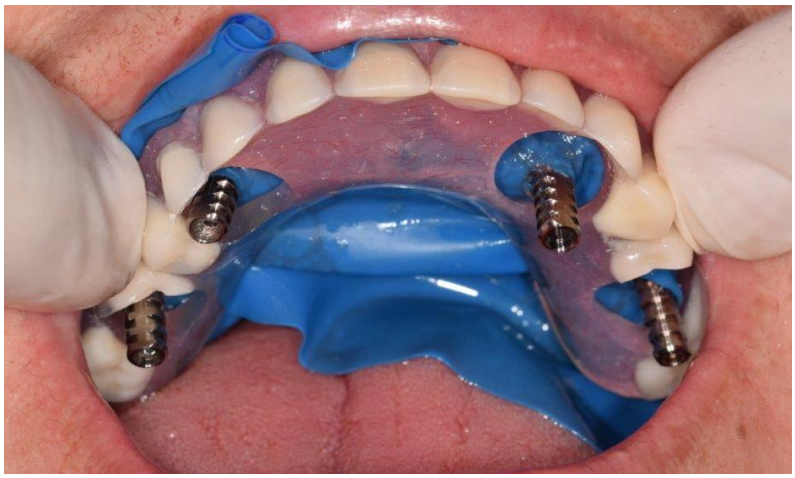

Fig 4. Rubber dam sheet perforated around the abutmentsthenPick up of the metal caps to the denture base

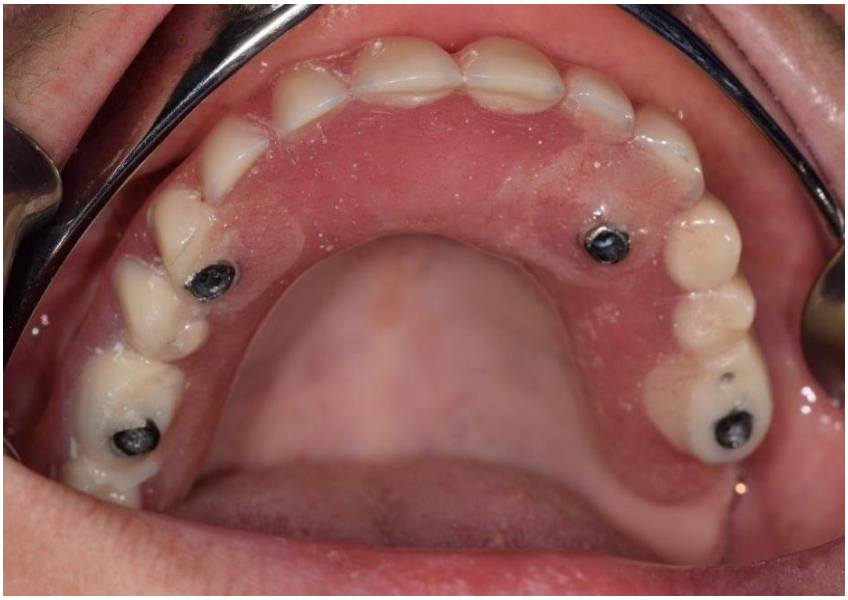

Fig 5. Finished and polished and temporary denture was screwed to the multiunit abutment

3) Post-operative procedures

- Post-operative medications: analgesics to relieve pain, systemic antibiotic cover (Augmentin® 1gm) for 10 days, a chlorhexidine digluconate 0.2% mouth rinse for 2 weeks and topical application of anti-inflammatory gel to the peri-implant area. Anti-inflammatory medication was prescribed post surgically from days 5 to 10. Cortisone medication was given daily in a regression mode (15 mg to 5 mg) from the day of surgery until 4 days postoperatively. Analgesics were given on the day of surgery and postoperatively for the first 3 days if needed.
- Post-operative instructions include:

a. Participants were instructed for oral hygiene procedure as softly brush the healing abutments, use mouth wash and careful clean around the implants to avoid accumulation of plaque around the healing abutments which may lead to peri-implantitis in the critical healing period.

b. Regular follow-up visits (twice/ week for 3 weeks and once/week for 3 months) to perform adjustments of the temporary dentures and verify oral hygiene practice till osseointegration occurs.

- Postoperative panoramic radiograph was made (fig 6)

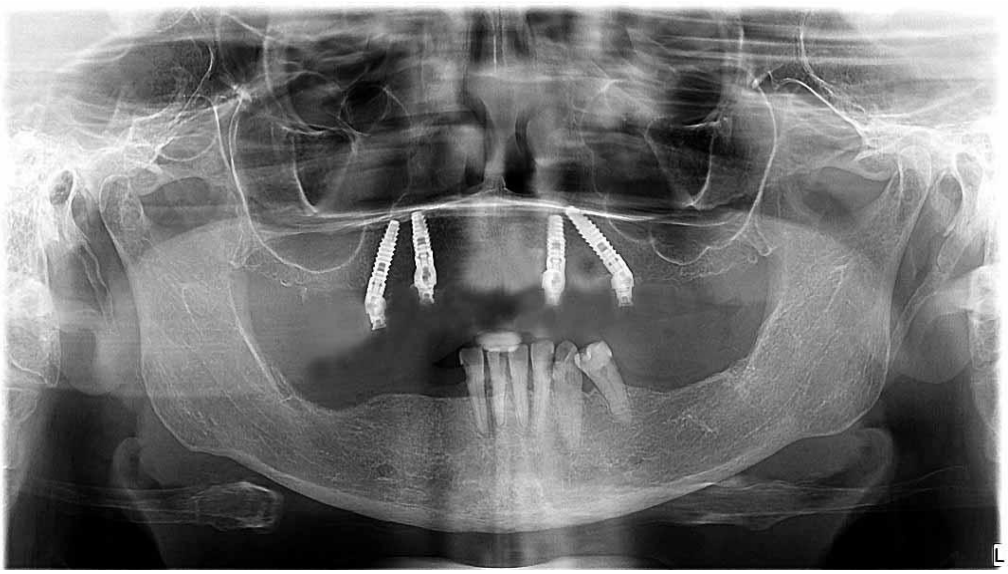

Fig 6. Postoperative panoramic radiograph

V. Prosthetic protocol

- After 6 months of osseointegration period, a master cast was obtained by open tray impression procedure on which fixed prosthesis was constructed.

A) Open tray(abutment level) impression procedures

- An acrylic resin splinting bar was constructed on the cast to splint the transfer coping during the final impression procedure and to obtain a passive fit casting

Splinting of transfer copings on the master cast was made by Duralay resin (Duralay, Reliance Dental MFG Co, Worth, IL, USA)bar supported by orthodontic ligature wire (Fig 7).

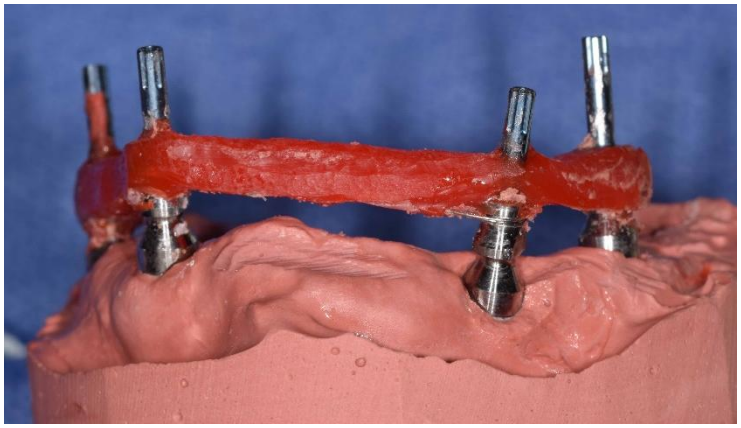

Fig 7. Splinting of transfer copings on the master cast with Duralay resin

- The resin splinting bar was sectioned into 4 segments with 3 disc cuts between transfer copings
- The copings with attached resin bar segments were screwed to the multiunit abutments in patient mouth (fig 8)
- The bar segments were picked up intraorally with Duralay resin to split the coping for passive fit (fig 9)
- A stock tray was perforated opposite to the copings to allow passage of long screws of the copings without interference
- The light body rubber base impression was injected around the transfer coping. Fill the tray with a heavy body impression material and insert it intraorally till the tips of all the guide pins are appeared, clean the guide pin access holes from excess impression material.
- The impression copings were unscrewed and the impression was removed from the patient mouth. (Fig 10)
- Titanium metal caps were screwed to multiunit abutments and an acrylic resin jig connecting the caps was fabricated on the cast to verify passive fit and accuracy of impression before construction of the final prosthesis (fig 11).
- The acrylic jig was screwed to multiunit abutments intraorally to verify passive fit. The passivity of the resin jig was tried in the patient mouth using single screw test of Sheffield; a one screw was tightened into one of the distal abutments, no lifting of the jig should occur. Repeat the method for each abutment.

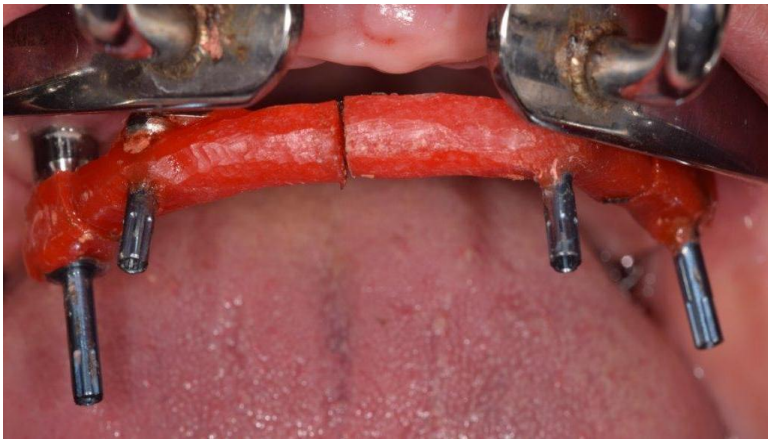

Fig. 8. Screwing of the copings with attached resin bar segments to the abutments

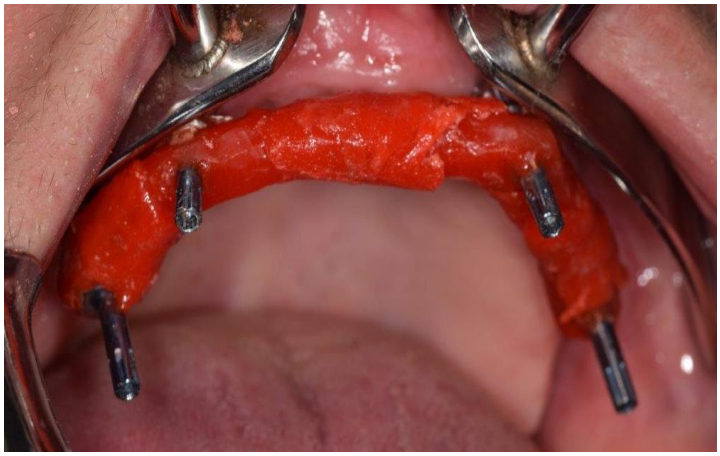

Fig 9. Pick up of the bar segments intraorally with Duralay resin for passive fit

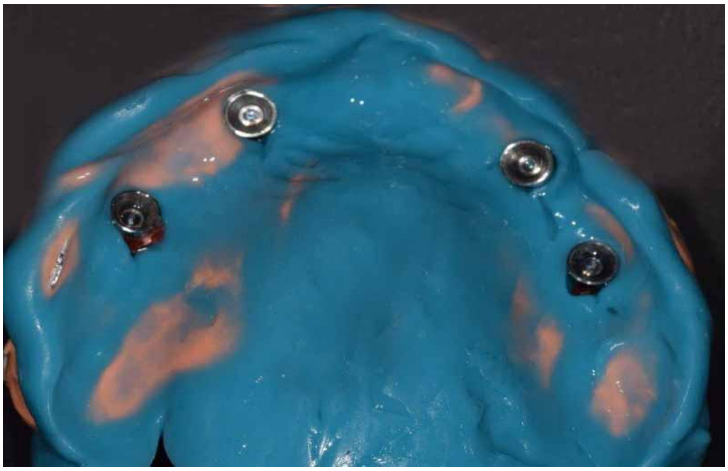

Fig 10. Finished impression

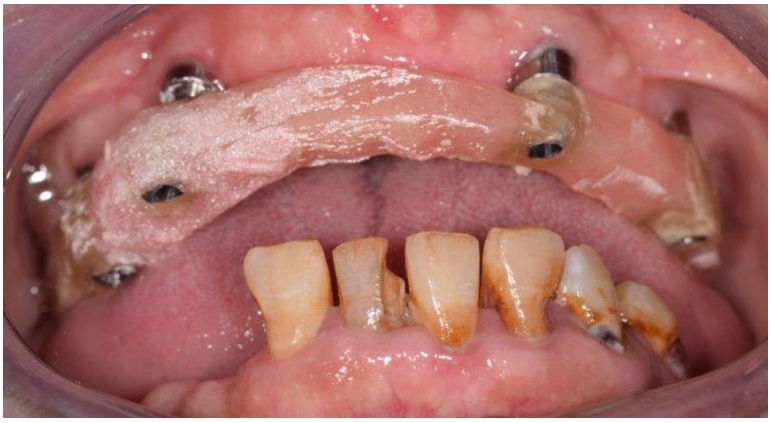

Fig 11. Verification of the passivity of the jig intraorally

B) Construction of fixed prosthesis

- The fixed final prothesis was in the form of screw retained hybrid prosthesis
- The fixed restoration was constructed from porcelain fused metal and pink porecelain to replicate gingival tissues
- The bridge was screwed to the abutment at 20 Ncm torque, oral hygiene measures were reviewed. (Fig 12)
- After prosthesis insertion, the patients were instructed for strict oral hygiene measures.
- Two weeks after insertion the patients were recalled every 3 days for denture review.

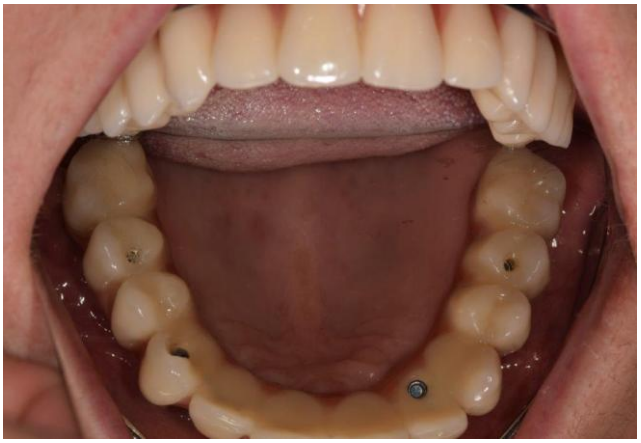

Fig 12. Insertion of the finished restoration

D- Evaluation of per-implant tissues

- Evaluation of peri-implant tissues was made at time of immediate loading of the implants with acrylic dentures (T0), 6 months (T6) and 12 months later (T12).

1. Clinical evaluation

- The parameters for peri-implant tissue health evaluation included: plaque index, bleeding index, per-implant probing depth and implant stability.

1- Assessment of plaque index;

- Modified plaque index[8] scores used to assess the plaque index. A plastic periodontal probe(Vivacare TPS, Vivadent, Schaan, Liechtenstein) was run along the marginal area around each implant.

2- Assessment of bleeding (gingival) index:

- Modified bleeding index[8] were used to assess the score. Score 0; when periodontal probe is passed along the gingival margin no bleeding occurs, score 1; isolated bleeding spots, score 2; confluent red line of bleeding on gingival margin, and score 3; heavy or perfuse bleeding.

3- Assessment of peri-implant probing depth:

- Using a calibrated plastic periodontal probe, measure the distance between marginal gingiva and the tip of the probe and considered as pocket depth (PD).[9]

4- Assessment of implant stability:

- Resonance frequency analysis was used to measure implant stability after removal of multiunit abutments and attachment of the smart pegs to the fixtures. The Osstell® device (Integration Diagnostics Ltd.) measured the stability using the implant stability quotient (ISQ).
- The measurements were done 3 times and the mean was subjected to statistical analysis.

2. Radiographic evaluation

- Peri-implant marginal bone resorption was evaluated using the long-cone standardized periapical radiography
- Periapical x-rays captured by a digital device (Digora, Soredex) was made.
- A film holder designed specifically for implant imaging (Rinn XCP, Rinn Co., dentsply, USA.) were used for intraoral radiograph.
- To maintain the same film–implant distance and cone implant distance, a modification was carried out for the film holder.
- This modification is a hole drilled exactly above the implant fixture so the distance was maintained during subsequent film exposures.
- A long screw of the impression coping is used to secure the holder to the implant. Through this modification, standardized radiographs were achieved.
- Detect magnification error by comparing the implant dimensions in the radiographs with the actual implant dimensions. This ratio allows us to obtain the actual values of the bone changes.
- The digital images were traced using the accompanying software (fig13) and bone height was measured as the distance between implant-abutment junction and first bone- contact (A-B distance) [10, 11-13].
- Bone resorption was calculated by subtracting bone height values at T6 and T12 from values at T0.

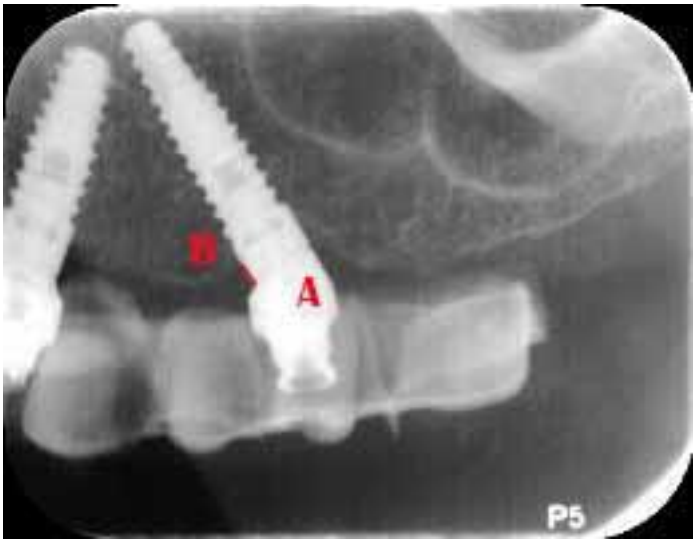

Fig 13. Periapical X-ray with reference lines and points

- Alveolar bone changes were measured mesially and distally and the mean was subjected to statistical analysis.

Statistical analysis

The data was analyzed using the SPSS software version 22 (SPSS Inc.).One-Sample Kolmogorov-Smirnov and Shapiro Wilk tests were used to diagnose normality of data distribution of all variables. PI, GI was presented as median (minimum- maximum) and PD, ISQ, and VBL was presented as mean±SD. Comparison of plaque index, gingival index, pocket depth, implant stability, and bone resorption between time intervals was made using Freidman and Wilcoxon signed ranks test. Comparisons between implant positions (anterior and posterior) were made using Mann Whitney test. The level of significance was set at $p<0.05$.

III. Results

I. Clinical parameters

A. Plaque scores

1. Comparison between observation times:

Comparison of plaque scores between observation times is presented in (table 1). Plaque scores significantly increased with advance of time for anterior implants and posterior implants. Multiple comparisons of plaque scores between each 2 observation times was presented in the same table. There was a significant difference between each 2 observation times for anterior and posterior implants

2. Comparison between anterior and posterior implants

Comparison of plaque scores between anterior and posterior implants at different observation times is presented in (table 1). No significant difference of plaque scores between anterior and posterior implants was noted at all observation times. (P>.005).

B. Gingival scores

1. Comparison between observation times:

Comparison of gingival scores between observation times is presented in table 1. No significant difference in gingival scores between observation times was noted for anterior implants and posterior implants. Multiple comparisons of gingival scores between each 2 observation times were presented in the same table.

2. Comparison between anterior and posterior implants

Comparison of gingival scores between anterior and posterior implants at different observation times is presented in (table 1). No significant difference of gingival scores between anterior and posterior implants was noted at all observation times. (P>.005).

C. Pocket depth

1. Comparison between observation times:

Comparison of pocket depth between observation times is presented in (table 2). Pocket depth significantly increased with advance of time for anterior implants and posterior implants. Multiple comparison of pocket depth between each 2 observation times was presented in the same table. There was a significant difference between each 2 observation times for anterior and posterior implants

2. Comparison between anterior and posterior implants

Comparison of pocket depth between anterior and posterior implants at different observation times is presented in (table 2). No significant difference of pocket depth between anterior and posterior implants was noted at all observation times. (P>.005).

D. Implant stability

1. Comparison between observation times:

Comparison of implant stability between observation times is presented in (table 2). Implant stability significantly decreased at T6 and significantly increased again at T12 for anterior implants and posterior implants. Multiple comparison of implant stability between each 2 observation times was presented in the same table. There was a significant difference between T0 and T6 and between T6 and T12, however no significant difference was observed between T0 and T12 for anterior and posterior implants

2. Comparison between anterior and posterior implants

Comparison of implant stability between anterior and posterior implants at different observation times is presented in (table 2). No significant difference of implant stability between anterior and posterior implants was noted at all observation times. (P>.005).

II. Radiographic parameters

Vertical bone loss

1. Comparison between observation times:

Comparison of Vertical bone loss between observation times is presented in table 2. Vertical bone loss significantly increased at T12 compared to T6 for anterior implants and posterior implants.

2. Comparison between anterior and posterior implants

Comparison of Vertical bone loss between anterior and posterior implants at different observation times is presented in (table 2). Vertical bone loss for anterior implants was significantly higher than posterior implants at T6 and T12. (P<.001).

Table1: Comparison of PI and GI between different observation times and between groups

	T0 M(min-max)	**T6 M(min-max)**	**T12 M(min-max)**	**Freidman test (P value)**
	Plaque index			
Anterior implants M(Min-Max)	.00(.00-.01) A	1.00(1.00-.300) B	2.00(1.00-3.00) C	<.001*
Posterior implants M(Min-Max)	0.00(.00-1.00) A	1.00(1.00-2.00) B	2.00(1.00-3.00) C	<.001*
Mann-Whitney Test (p value)	.26	.82	.81	
	Gingival index			
Anterior implants M(Min-Max)	.00(.00-1.00) A	.00(0.00-1.00) A	0.00(0.00-1.00) A	.89
Posterior implants M(Min-Max)	.00(.00-1.00) A	.00(0.00-1.00) A	0.00(0.00-1.00) A	.88
Mann-Whitney Test (p value)	1.00	.68	.68	

M; median, min; minimum, max; maximum, * p is significant at 5% level. Different letters in the same raw indicates a significant difference between each 2-observation time (P<.05)

Table 2: Comparison of PD, ISQ and VBL between different observation times and between groups

	T0 X±SD	**T6 X±SD**	**T12 X±SD**	**Wilcoxon signed ranks test(P value)**
	Pocket depth			
Anterior implants X±SD	.30±.47 a	1.4±.28 b	1.9±.29 c	<.001*
Posterior implants X±SD	.25±.44 a	1.5±.23 b	2.00±.26 c	<.001*
Mann-Whitney Test (p value)	.72	.27	.27	
	Implant stability			
Anterior implants X±SD	65.4±1.14 a	62.8±1.30 b	65±.70 a	.019*
Posterior implants X±SD	66.2±.83 a	64±1.00 b	65.8±.84 a	.016*
Mann-Whitney Test (p value)	.23	.216	.14	
	Vertical bone loss			

Anterior implants X±SD	-	1.60±.46 a	2.00±.47 b	.001*
Posterior implants X±SD	-	.60±.30 a	1.00±.30 b	.001*
Mann-Whitney Test (p value)	-	<.001*	<.001*	

X: mean, SD: standard deviation. * P is significant at 5% level. Different letters in the same raw indicates a significant difference between each 2-observation time (Mann- Whitney test, p<.05)

IV. Discussion

The "all on four concept" uses the simplicity of posterior tilted implant to create full arch restoration that can be less clinically invasive for patient with immediate function[14]. This concept had become widely accepted and consisted of fixed prosthesis supported by four endosseous implant (two axial implant in the anterior segment and one distal implant on each posterior segment tilted posteriorly with implant apex are to engage cortical bone anterior to maxillary sinuses. The increased anterior posterior spread from the tilted implant generally provide first molar occlusion for patient with short cantilever segment. [15, 16]

The ''All-on-4^{TM}'' concept allows basically for two different types of superstructures, a metal-ceramic implant-supported fixed prosthesis with a titanium framework and all-ceramic crowns and a metal-acrylic resin implant-supported fixed prosthesis with a titanium framework and acrylic resin prosthetic teeth. In addition, bar retained removable acrylic superstructures can be used as an alternative to the metal-acrylic resin implant-supported fixed prosthesis. [17-20]

The chance of developing the so-called combination syndrome was observed in patients with an edentulous maxilla opposing a shortened dental arch in combination with a prosthetic device in the mandible as a result of occlusal load caused by excessive anterior function [1]. This will result in loss of bone from the anterior part of the maxillary ridge with flappy tissue due to increase in anterior occlusal load. Reviewing the literature, the use of "All on Four" implant supported fixed screw retained prosthesis in rehabilitation of edentulous maxilla was proved to be an efficient and successful long-term prosthetic solution. However, the evaluation of peri-implant tissue health with this kind of rehabilitation when the opposing mandibular arch contain only remaining anterior teeth and distal extension RPD was not a concern. Therefore, the aim of the present study was to evaluate peri-implant tissue health after rehabilitation of edentulous maxilla complicated with combination syndrome with All on Four Implant supported fixed prosthesis opposing distal extension mandibular RPD.

Plaque scores significantly increased with advance of time for anterior implants and posterior implants. This might be attributed to the fact that performing adequate oral hygiene is difficult especially in the region of abutments and under the prosthesis due to limited access for cleaning by the patient and decreased manual dexterity of old patients. In contrast with this finding, Agliardi et al, [21] found a progressive decrease in plaque and bleeding scores was observed in the first year. However, their study was the clinical and radiographic evaluation of immediately loaded fixed mandibular prosthesis supported by implants inserted according to All-on-Four® technique, up to 5 years of function.

No significant difference of plaque and gingival scores between anterior and posterior implants was noted. Similarly, in other studies, no difference in clinical and radiographic outcomes was reported between tilted and axial implants.[16, 22-24]. Also Agliardi et al [21] evaluated the clinical and radiographic outcomes of immediately loaded full-arch fixed prostheses supported by a combination of axially and non-axially positioned, up to 5 years of function. They found that no difference was found in marginal bone loss between axial and tilted implants.

No significant difference in gingival scores between observation times was noted for anterior implants and posterior implants. In contrast with this finding, Agliardi et al. [21] found a progressive decrease in bleeding scores was observed in the first year, and they attributed this finding to lowest plaque accumulation, which depends on patient's personal oral hygiene maintenance. A possible explanation of lack of difference in gingival scores between observation times might be attributed to the effect of the width of keratinized mucosa on gingival index. The maxillary edentulous ridges had sufficient keratinized mucosa compared to mandibular ridges. According to Adibrad et al[25], functional dental implants had significantly higher scores for plaque accumulation, bleeding on probing, mucosal inflammation and recession when they lack an adequate zone of keratinized mucosa. It was elaborated that implants with a narrow zone of keratinized mucosa were prone to bleeding on probing more often than for implants with a wider zone of keratinized mucosa

Pocket depth significantly increased with advance of time for anterior implants and posterior implants. The increased pocket depth could be attributed to the increased VBL around implants as confirmed by the results of VBL in this study. This possible speculation might be in consistent with Elsyad et al [11]who reported an increase in PD measures immediate loading implant. They related this to an increase in peri-implant soft tissue enlargement and peri- implant bone resorption. In agreement with this observation, several authors reported an

increase in pocket depth around implants supporting "All on four" prosthesis [26, 27]. The increased pocket depth with time may be attributed to the, plaque indices, gingival indices, marginal bone resorption and mucosal enlargement [28]. No significant difference of pocket depth between anterior and posterior implants was noted. Similarly, Krennmair, et al.[26] found that pocket depth did not differ between anterior and posterior implants. Elsyad et al [27] in a recent study found that for fixed prosthesis, pocket depth of anterior implants was significantly higher than posterior implants after 6 months and this difference disappeared after 12 months.

Resonance frequency analysis was used to evaluate implant stability as it is noninvasive method that allows verification of implant stability during healing and in subsequent evaluations[29]. It has been reported in the literature that implants with stability greater than 60 ISQ can be immediately loaded[30]. Implant stability values obtained in all observation times was above 60.

Implant stability significantly decreased at T6 and significantly increased again at T12 for anterior implants and posterior implants. The decrease in implant stability at T6 may be attributed to the decreased bone to implant contact after immediate loading by provisional denture due to reduced bone density and fine trabecular bone of maxillary ridge. The implant stability in this study increased at T12 again. This may reflect the increased bone to implant contact at the interface after bone remodeling and maturation process of osseointegration[31]. No difference in implant stability was noted anterior and posterior implants. This may be due to all implants are inserted in maxillary anterior bone which characterized by the same bone quality and density. Another reason of good implant stability for both anterior and posterior implants was the splinting of the implants by fixed prosthesis which distribute the functional loads equally on all implants [32]. The lack of difference in implant stability between anterior (vertical) and posterior (tilted) implants was in line with results of other studies[33, 34, 35]. This may be due to tilted implants allowed the use of longer implants, which increase the bone to implant contact[27]. Also, the cross-arch stabilization of the implants by fixed prosthesis minimizes the individual implant micromovement after prosthesis insertion[35].

The mean VBL of anterior implants was 2.00±.47 mm after 12 months. Similarly, Malo et al.[22], reported that the marginal bone level was, on average, 1.52 mm (standard deviation [SD] 0.3 mm) for immediate function of four implants (All-on-4™) supporting a fixed prosthesis in the completely edentulous maxilla.This value was far higher than the VBL obtained by Krennmair et al.[36] around vertical implants supporting milled bar in edentulous maxilla (2.2± 0.6). Browaeys et al assessed the marginal bone loss of implants immediately loaded with an All-on-4 full-arch screw-retained prosthetic bridge in fully edentulous mandibles or maxillae over up to 3 years. They found that the mean bone loss between the 1-year and 3-year follow-ups was 0.48 mm. This difference indicative of ongoing bone loss. They concluded that unacceptable ongoing bone loss was seen in 49.2% of the patients; this may be a warning sign for future problems. [37]

Vertical bone loss significantly increased at T12 compared to T6 for anterior implants and posterior implants. The increased vertical bone loss with advance of time could be attributed to increased mechanical stresses which may produce fatigue micro-damage resulting in bone resorption[38]. Such stresses may be related to the following factors: 1) The fine trabecular maxillary bone with absent cortical plate may subject the maxilla to higher biomechanical forces[39], 2) The thick masticatory mucosa on the maxilla often necessitates longer implant abutments which increases the lever arm length[40], 3)The immediate loading of implants during the healing period could lead to greater bone over load which may exceed physiologic threshold[41] as the implants have less mechanical anchorage[42]

Vertical bone loss for anterior implants was significantly higher than posterior implants. Similarly, Calandriello and Tomatis [43] found a lower bone loss values for tilted implants supporting fixed prosthesis, as compared with upright ones. In contrast with this finding, Francetti et al. [44] assessed immediately loaded full-arch fixed bridges anchored to both tilted and axially placed implants (All-on-Four®) and compared the outcome of axial versus tilted implants, and found no significant difference in marginal bone loss was found between tilted and axial implants at 1-year evaluation.

The increased bone loss around anterior implants could be attributed to progressive tilting and settling of the mandibular RPD under masticatory forces which transmit forces to the mandibular residual ridge via the tissue-supported posterior section of the RPD. This cause unfavorable loading of the anterior region of the edentulous maxilla [45,46, 47, 48] with subsequent increased occlusal force transmission to the anterior maxillary implants. In line with this explanation, Kreisler et al [49] in a retrospective study, found higher resorption in the anterior (5- 12%) than in the posterior part (2-7%) of the edentulous maxilla opposed by mandibular ovoid bar retained overdentures on 2 implants after 8 years. They attributed their finding to the transference of significant occlusal forces into the anterior maxilla with subsequent maxillary alveolar bone resorption and soft tissue inflammation.

The increased VBL around anterior implants compared to posterior ones was in agreement with Francetti et al [50]. Similarly, Wismeijer et al [51]reported that in cases with 4 interconnected implants, there was significantly more bone loss around the central 2 implants in comparison with the lateral 2 implants. Earlier studies of Lindquist et al 1988 and Ahlqivst et al 1990 reported a greater bone resorption around medially positioned implants in fixed retained prosthesis [51, 52, 53]. This could be attributed to the deformation of the fixed

prostheis metal substructure together with increased occlusal load transmission to the implants by porcelain teeth of the FP may be responsible for increasing VBL around anterior implants. Also the direction of the loading that is more vertical in the posterior area while it is more oblique in the anterior region.[54]

The limitations of this study include the small sample size, and the short follow up period. Moreover, the measurement of peri-implant outcomes did not include the first 6 months after immediate loading of the implants with provisional dentures. Therefore, future long term randomized controlled trials are needed to ensure the findings of this study. Further studies are also needed to evaluate peri-implant clinical and radiographic outcomes in the critical healing period after immediate loading of the implants with provisional restoration.

V. Conclusion

Within the limits of this study regarding the small patient sample and the short follow up time frame, it could be concluded that; All On Four® Implant supported fixed prosthesis for rehabilitation of edentulous maxilla complicated with combination syndrome was associated with favorable clinical and radiographic peri-implant tissues responses after one year. However, it should be noted that anterior implants were at higher risk of increased peri-implant bone loss compared to posterior implants

VI. Recommendation

Long term randomized controlled trials with sufficient sample size and long follow up period is needed to ensure the finding of this study and to evaluate success of dental implants (especially anterior implants), clinical and radiographic changes of the maxillary edentulous ridge, muscle activity, chewing efficiency, bite force, and patient bases outcomes of All on four maxillary fixed prothesis in treatment of edentulous maxilla opposed by remaining mandibular anterior teeth

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