Evaluation of Dental Implant Stability Regarding All-on-4 Concept Utilizing Two Different Angles

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Abstract

Background: The "All-on-4" technique using 4 implants that has gained popularity in full arch edentulism cases in recent years was presented as a modern technique in implant-denture rehabilitation by Malo in Lisbon, Portugal, for the first time in 2003 and the all-on-four concept that began to be used in atrophic full arch mandibular and in the maxilla in 2005 has emerged.

Aim: evaluation of dental implant stability in relation to All-on-4 concept.

Materials and Methods: This was a clinical prospective comparative study organized from February 2019 to March 2020 in the College of Dentistry Teaching Hospital, Department of Oral & Maxillofacial Surgery/ Dental Implant Unit/University of Baghdad. A total of 15 Iraqi patients aged 41-73 years, 9 males & 6 females were enrolled in this study receiving 80 Dental implants (All-on-4 concept). Patients classified into two groups, group A (All-on-4 with 2 anterior axial and 2 posterior with angulation of 17°) and group B (All-on-4 with 2 anterior axial and 2 posterior with angulation of 30°). For both, the surgical site of dental implant was examined for the hard and soft tissues clinically and radiographically utilizing OPG and CBCT.

Results: The mean of ISQ values obtained in this study at each time point in the total dental implant, axially placed and angled implant stability demonstrated significant increase (P = 0.000, 0.031 and 0.004) respectively at different times. There was a significant increase in the mean stability of axial and angled implants concerning males **(P = 0.001 and P =0.002)** respectively than females. Significant correlation between implant stability and the regions at the three times periods. There was a significant difference in angled implants stability between different intervals **(P = 0.001)** in patients >50y. Success of dental implants 95.24%.

Conclusion: All-on-4–style full-arch dental implant procedures have one of the highest success rates of dental treatment; the dental implant stability had significant effect in mandible in comparison to maxilla. There was irrelevant clinical analysis result in comparison to the statical analysis in relation to stability with different variables.

Keywords: *All-on-4, Implant stability and Dental implant.*

Introduction

All on 4 Concept Principle

In 1993, Dr Paulo Malo performed the pilot study to establish All-on-4 concept [(1)]. The design of the "All-on-4" immediate-function concept was developed in 2003 by Malo and colleagues [(2)], the approach to rehabilitate the fully edentulous mandibular jaw by placing only 4 implants in the following combination: 2 anterior implants placed axially and 2 posterior implants placed distally tilted within the mandibular parasymphyseal region .These implants were immediately loaded with a full fixed acrylic prosthesis within 2 hours of surgery

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[3]. Building on the mandibular "All-on-4" success, Malo and colleagues replicated the same design for the maxilla in 2005 [4].

Biomechanical advantages of "All-on-4" design [3].

1. Implants follow a dense bone structure.

2. Longer implants can be placed by tilting them posteriorly.

3. Tilting improves A-P spread of implants.

4. A-P spread enhances load distribution for prosthesis.

5. Shorten cantilever (maximum of 7 mm for maxilla and 1.5–2.0 _ A-P spread for mandible) reduces prosthetic fracture/instability and marginal bone height stability.

6. Marginal bone height of implants is maintained with rigid prosthesis.

7. Tilted implants have similar success rate as traditional implants when splinted together.

According to Sennerby and Meredith, 2008 and Sachdeva et al., 2016 dental implant stability can be divided into:

· Primary stability refers to the mechanical bracing of the implant in bone and absence of any micromovement.

· Secondary stability refers to successful osseointegration of the implant with the surrounding bone. The majority of implant losses may be explained as biomechanically induced failures, since low primary implant stability, low bone density, short implants and overload have been identified as risk factors

Resonance frequency analysis (RFA): **Meredith, Alleyne** [5] suggested a non-invasive method of analyzing peri-implant bone by connecting an L shaped transducer to an implant in an animal study. The transducer provides a high frequency mechanical vibration and record the frequency and amplitude of the signal received. The resonance frequency was thus defined as the peak of frequency- amplitude plot and converted to a value representing stiffness of bone implant interface [6].

A new generation of RFA technology has been developed by members of the original team behind the commercialisation of RFA (Integration Diagnostics Sweden AB, Gothenburg, Sweden). A small pen-like battery-driven instrument (PenguinRFA) is used together with reusable transducers (MulTiPeg™) as (Fig. 1.5B). These are made from biocompatible titanium and can consequently be autoclaved and used numerous times. The instrument can be packed in a sterile pouch and kept on the surgical tray and used without the assistance from a second person [7]. The instrument measures the frequency of the vibration and translates it to an ISQ scale value between 1 and 99. The higher the ISQ value, the better the stability. RFA measures implant stability as a function of interface stiffness, which correlates with implant displacement, i.e. micro-mobility. More than 700 references, ISQ> 70 represents "high stability", ISQ between 60 and 69, "medium stability", and ISQ <60 is considered "low stability[8]. Values above ISQ 70 indicate a very stable implant with low micro-mobility. This value is typically recommended for one-stage and immediate loading. A second measurement is recommended before the final restoration to verify osseointegration [9].

Materials and Methods

A total of 15 Iraqi patients aged 41-73 years, **9 males & 6 females** were enrolled in this study receiving 80 DI (All-on-4 concept).

Patients classified into two groups, **group A (All-on-4 with 2 anterior axial and 2 posterior with angulation of 17°)** and **group B (All-on-4 with 2 anterior axial and 2 posterior with angulation of 30°)**. For both, the surgical site of DI was examined for the hard and soft tissues clinically and radiographically utilizing OPG and CBCT.

The total performed implants was 80 DI was for both groups, 40 DI for each group.

Inclusion Criteria:

1. Patient's ≤18 years with complete jaw edentulism.

2. Patient was with good general condition or with other diseases that not influences BHP (like hypertension … etc.).

3. Completely edentulous maxilla and mandible or presence of teeth with an unfavorable long-term prognosis to be extracted.

4. Adequate available alveolar bone height and width in between premolars regions.

5. Patients who refused any kind of sinus augmentation procedure on undergoing any kind of Inferior Alveolar Nerve (IAN) transposition procedure (lateralization)when indicated.

Exclusion Criteria:

1. Presence of local acute infection at the implant site or any evidence of local pathological conditions in implant zone.

2. Poor oral hygiene and poor motivation to initiate/maintain good oral hygiene.

3. Any systemic diseases or condition that influence bone healing.

4. Anatomical limitation that interfere with the performance of this procedure.

5. Clinical evidence of parafunctional habits.

· **Clinical examination**:

A detailed medical, family and dental history were taken from the patients regarding any systemic diseases, smoking and other conditions that could influence bone healing. A clinical examination of the patient to evaluate regional lymph nodes, facial profile and symmetry, and temporomandibular joint function. The intraoral examination assessed mouth opening, oral hygiene, any clinical evidence of parafunctional habits.

· **Radiological examination**

A preliminary preoperative OPG was taken as a standard radiograph for documentation and assessment of the available alveolar bone height taking in consideration the amount of magnification and important anatomical structures such as (the anterior wall of maxillary sinus, floor of nasal cavity, mandibular canal and mental foramen and its loop), Also, it was important to identify the presence of any pathology in the implant zone and the relation of the proposed DI to the anatomical limitations. CBCT for indicated cases (candidates) was taken to evaluate the available bone of the maxilla and mandible in a 3-dimensions view.

Surgical Procedure

Prophylactic oral rinse with 0.2% chlorhexidine was performed about 1 minute before surgery. Topical spray anesthesia of Lidocaine 10% was applied to the buccal\palatal and lingual mucosa to decrease pain of local anesthesia. Surgical procedures were performed under local anesthesia infiltration with Lidocaine 2% (Septodent). A crestal incision was made from first molar to first molar region with distally bilateral buccal vertical oblique incision, full-thickness mucoperiosteal flap reflection using Molt # 9 and\or Haworth periosteal elevator was performed to locate a bluish hue and bulge of maxillary sinus to determine anterior boundary of maxillary sinus and attention to locate and avoid damaging the mental nerve and locating neurovascular bundle clinically with direct vision, alveolar osteotomy was made with surgical bur, The ridge crest was trimmed to remove any sharp edges and irregularities using surgical bur and surgical hand piece with copious irrigation of normal saline solution , as seen in Figure (1A).

After drilling with a ⌀ 2.4 mm drill to 10-mm depth using a dental engine handpiece set at 800 rpm and torque equal to 35 N/cm, an All-on-4 Guide (Trigonometer, Nucleoss Turkey) was placed in the midline. The contour of the guide should be adjusted so as it follows the opposing arch; this allows implants to be directed against the opposing arch for proper inclination, as presented in Figure (1B).

Starting with the anterior implant sites, drilling with a pilot drill (starter drill) at least 10 mm from the previously midline guide (lateral incisor position) according to jaw size and anatomical variation, sequential drilling until reaching the final size with 0°. The two axially anterior implants were installed in the anterior region parallel to the midline following the jaw axially to avoid buccal bone plate penetration, Implant placed with 35 rpm speed using motorized way and then finally seated with manual ratchet Figure (1C&D).

Posterior implant position at second premolar position with the same technique and insertion torque. The exact location of the anterior wall of maxillary sinus was important to be located and with attention to locate and avoid damaging the mental nerve and neurovascular bundle clinically with direct vision because it allows the posterior implants to be placed angulated distally with either 17°or 30° with respect to the guide and with anterior wall of maxillary sinus according to group selection as illustrated in Figures (E & F).

After the instillation of dental implants in their position using same speed and torque, a multipeg on each fixture was applied and measure the primary implant stability at time of surgery mesio-distally and bucco-lingually using penguin® device, as demonstrated in Figure (1G).

This step was followed by seating the multiunit abutment on implant fixture. Wound closure was performed with interrupted (3/0) black silk suture.

Within 72 hours, the provisional denture was inserted with the use of temporary multiunit collar asdemonstrated in Figure (2A&B).

The stability was measured after 12 weeks and 24 weeks. The metal framework and final restoration was performed after 12 weeks. A passive fit was essential to ensure accuracy and not to translate undue strain onto the implants. The occlusal contacts were adjusted. Regarding the screw-retained restoration, the abutments and restorations were gently tightened to the implant bodies using a manual screwdriver to facilitate it is opening as seen in Figure (2C&D).

Results

Distribution of patients data concerning the age and gender

Fifteen patients contributed to this study aged from 41-73 years with an average of 59.8 years. The highest percentage (**73.3%)** was reported >50y this study included 9 males and 6 females (**60%** vs **40%)** respectively with a male to female ratio of **1.5:1.**

Distribution of dental implants (DI) per patients according the gender in each jaw

Eighty-four DI were installed in twenty-one jaws according to All-on-4 concept, one case dropped out after four weeks. Nine male patients (twelve jaws) were contributed in this study with six females (eight jaws).

The effect of time on the dental implants stability.

Table (1) explain the statistical correlation between dental implants stability in ISQ that were installed in axial (anterior), angled (posterior) direction in relation to time interval **T1** (baseline), **T2** (12 weeks) and **T3** (24 weeks). In the total DI, axially placed and angled implant stability demonstrated **significant increase (P = 0.000, 0.031 and 0.004)** respectively at different times.

Relation of gender and times differences regarding the stability of dental implants

There was a significant increase in the mean stability of axial and angled implants concerning males (**P = 0.001 and P =0.002)** respectively, on the other hand, the axial inserted implants stability presented a significant correlation between gender at T2 & T3 (**P =0.010 & 0.023)** as explained in a table (2).

Age and time differences regarding the stability of dental implants

There was significant difference in angled implants ISQ between different intervals (**P = 0.001**) in patient >50y.

Jaws and time difference regarding the stability of dental implants

Regarding to mandible there was a **significant** difference in the mean of ISQ values at different periods (**p = 0.024)** as explained in a table (3).

Angle and time differences in the posterior region regarding the stability of dental implants

The posterior implants were inserted at two different angles (17º and 30º), there was no significant difference in ISQ value concerning DI angle at each time data. Furthermore, there was a **significant** difference in the mean of implant stability for DI inserted at (30º) **(P=0.040**) as demonstrated in the table (4).

Survival rate

The total number of DI installed in the study was **84**. Four dropped out of the total number due to failure during healing period. All implant undergoes early loading and success rate was 95.24%.

Table 1: Correlation of the effect of time on the stability of dental implants.

Variable	Time	Descriptive statistics					Time difference
		No.	Mean	S.D.	Min.	Max.	p-value
Total	T1	20	73.34	3.70	65.10	78.25	0.000**
	T2	20	74.42	3.51	65.30	80.50	
	T3	20	74.76	3.72	65.75	80.75	
Anterior (Axial)	T1	20	72.84	4.66	60.00	79.25	0.031*
	T2	20	73.69	4.41	62.00	80.75	
	T3	20	74.09	3.97	64.75	80.75	
Posterior (angled)	T1	20	74.19	4.17	64.75	80.50	0.004**
	T2	20	75.50	3.02	71.00	80.50	
	T3	20	75.96	3.29	68.00	80.75	

Highly significant = **, significant = *, Min. =Minimum, Max. = maximum, No. = Number, S.D. = standard deviation

Table 2: Descriptive statistics and gender difference regarding the stability of dental implants.

Variable	Time		Descriptive Statistics				Gender difference
			Males (No.=12)		Females (No.=8)		
			Mean	S.D.	Mean	S.D.	p-value
Total	T1		74.38	3.07	71.79	4.23	0.130
	T2		75.71	2.77	71.98	4.54	0.034*
	T3		75.93	3.25	73.02	3.89	0.086
	Time difference	F-test	11.34		1.82		
		p-value	0.000**		0.215		
Ant.	T1		74.35	3.38	70.56	5.57	0.073
	T2		75.65	3.03	70.75	4.67	0.010*
	T3		75.69	3.20	71.69	3.95	0.023*
	Time difference	F-test	11.10		0.79		
		p-value	0.001**		0.412		
Post.	T1		74.40	3.46	73.88	5.31	0.793
	T2		75.77	3.07	75.09	3.11	0.636
	T3		76.17	3.76	75.66	2.65	0.744
	Time difference	F-test	8.68		1.43		
		p-value	0.002**		0.274		

Table 3: Descriptive statistics and jaw difference regarding the stability of dental implants.

Variable	Time		Descriptive Statistics				Jaw difference
			Maxilla (No.=9)		Mandible (No.=11)		
			Mean	S.D.	Mean	S.D.	p-value
Total	T1		70.34	3.00	75.80	2.04	0.000**
	T2		71.21	3.69	76.67	1.98	0.001**
	T3		71.76	3.12	77.22	1.94	0.000**
	Time difference	F-test	2.48		6.69		
		p-value	0.127		0.024*		

Cont... **Table 3: Descriptive statistics and jaw difference regarding the stability of dental implants.**

Axial	T1		69.56	4.39	75.52	2.85	0.002**
	T2		71.06	4.38	75.84	3.19	0.011*
	T3		71.42	3.43	76.27	2.96	0.003**
	Time difference	F-test	3.89		1.14		
		p-value	0.055		0.319		
Angled	T1		70.89	3.65	76.89	2.13	0.000**
	T2		73.06	2.29	77.50	1.83	0.000*
	T3		73.28	2.54	78.16	1.91	0.000*
	Time difference	F-test	4.98		2.58		
		p-value	0.026*		0.138		

Table 4: angle and time differences in the posterior region regarding the stability of dental implants.

Time		**Descriptive Statistics**				**Angle difference**
		17º (No.=10)		**30º (No.=10)**		
		Mean	**S.D.**	**Mean**	**S.D.**	**p-value**
T1		74.78	4.86	73.60	3.50	0.543
T2		76.05	3.03	74.95	3.07	0.430
T3		77.18	2.56	74.75	3.62	0.101
Time difference	F-test	3.89		5.03		
	p-value	0.072		0.040*		

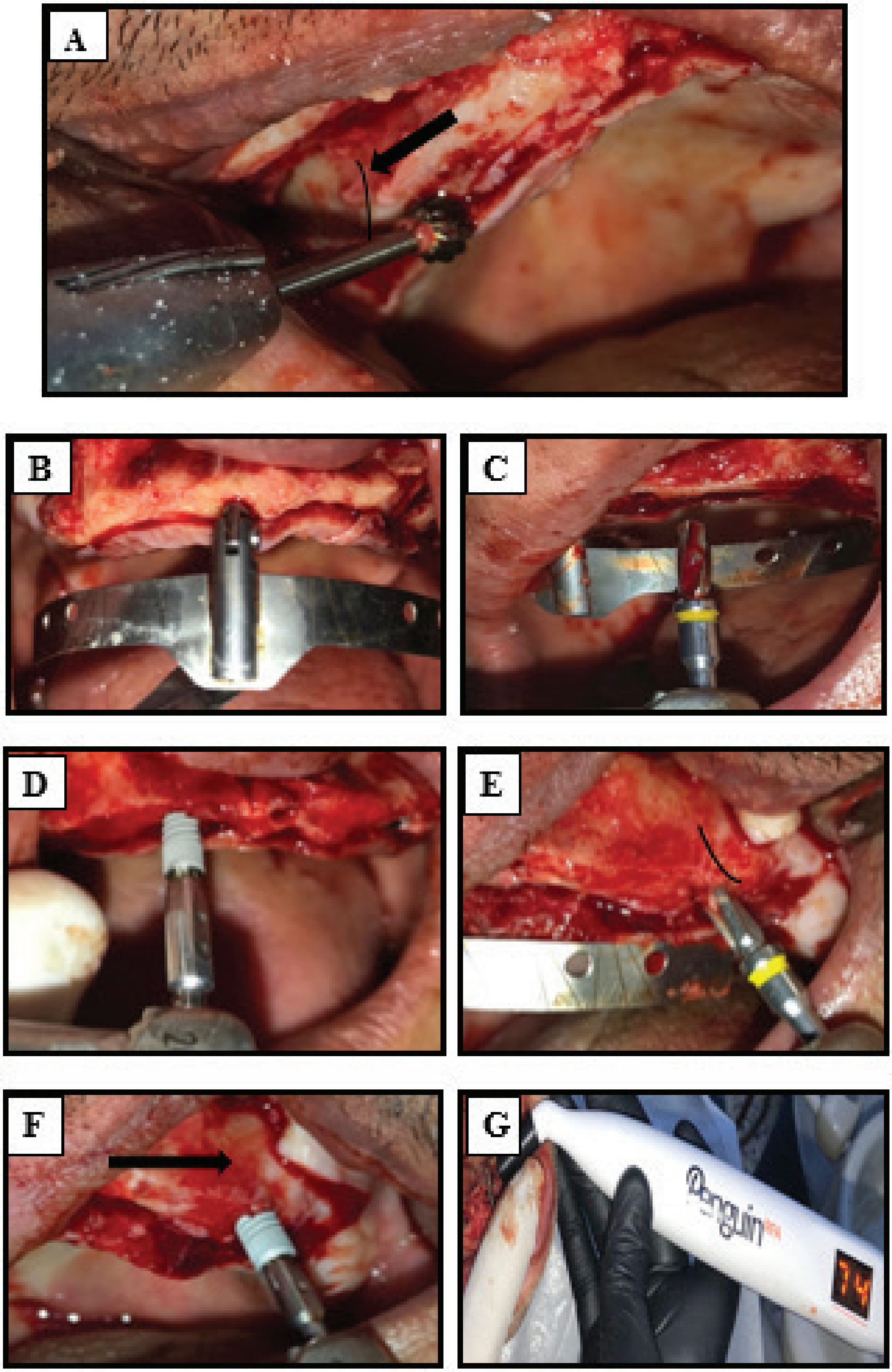

Figure 1 (A) bluish hue and bulge of maxillary sinus and osteotomy of alveolar ridge. (B) Trigonometer placement in the midline following the opposing arch. (C) Drilling with final drill (D) Installation of anterior implant at 0º. (E) Drilling of posterior implant at 30º. (F) Installation of posterior implant at 30º. (G) Measurement of implant stability by penguin and multipeg intraoperatively.

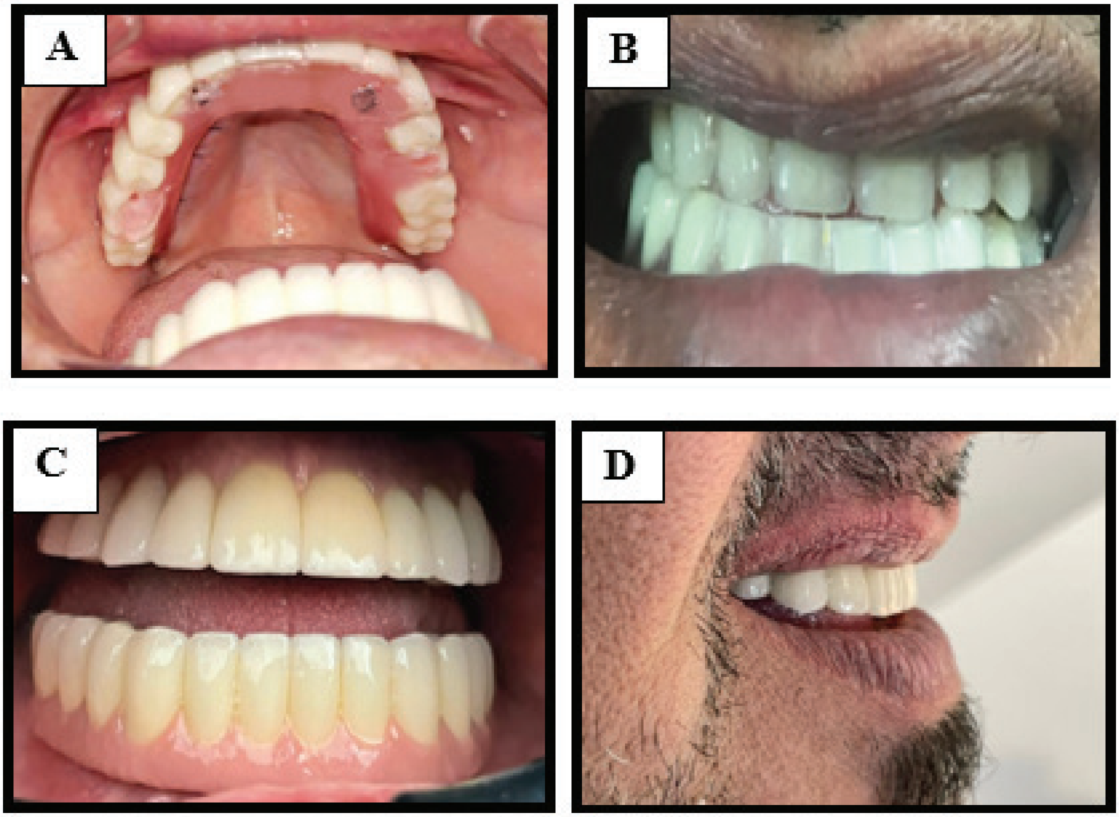

Figure 2: (A), (B) Insertion of screw retained provisional denture within 72 hours. (C), (D) Final prosthesis inside patient's mouth

Discussion

Dental implant stability in all-on-4 design in the current study, the mean of the 2nd measurement of total DI stability (12 weeks following DI placement) was **significantly increased** when compared with the primary stability (baseline) with values of **74.42** vs **73.34** respectively. Furthermore, the 3rd reading (24 weeks following DI placement) was **significantly increased** also compared to the primary stability and the 2nd measurement after the healing period (**74.76** vs **73.34** and **74.42**) respectively. However, there was significant increase in both axial and angled insertion dental implants separately **(P= 0.031 and 0.004)** respectively.

One important point to mention is that the increase in stability may be attributed to that all of DI were placed in the anterior region of maxilla and mandible. the bone of the anterior mandibular region presents higher bone density than the posterior mandible, followed by anterior maxilla, this opinion is supported by Farré [10] who stated that there was a significant statistical relationship obtained between the implant location and Hu and was in turn between the location and primary stability in terms of ISQ measurements.

All the initial measurements of DI stability registered higher than 60 ISQ so there was a contrast with Suzuki [11] who found that The ISQ values increased when the initial ISQ is lower than 60 ISQ, whereas ISQ values mostly stay unchanged or decreased when the initial ISQ is higher than 60 ISQ.

The present study is supported by Olsson [12] who examined a total of 61 oxidized implants (6 or 8 implants per maxilla). The mean ISQ, which was 60.1 at placement and increased to 62.8 after 4 months.

Hassan and Emarah [13] is contradict **in** their study with the present research, they reported two groups, Group 1 included 5 patients received all on four maxillary prosthesis, and group 2 included 5 patients received all on six maxillary prosthesis. The Implant stability significantly increase from base line (60) to (62) after 6 months then insignificantly increased at 12 months (63). The reduced number of the implants in-group 1 may subject the implants in this group to higher biomechanical load, which may decreased percentage of bone to implant contact and decrease implant stability. In contrast, wide implant distribution in the group 2 may cause physiologic loading of the bone, thus increasing the implant stability.

In the present study, there was a significant change in stability for males 9 (60%) than females (40%) **(P=0.000 and 0.215)** respectively this may be related to the small sample size.

On the other hand there was a significant change in implant stability in both axial and angled dental implants separately **(P= 0.031 &0.004)**, This is in close relation to the study performed by Wentaschek [(14)] who stated that the mean ISQ value for osseointegrated of 57 all on six implants after 3 months was significantly higher ($p < 0.001$) than their means at baseline. The DI were separated into axial (No. = 39) and tilted (No. = 18) implants, the differences were also significant ($p < 0.005$).

The patients that were treated according to all-on-4 concepts presented with significant change in total DI stability in relation to mandible than maxilla (**P=0.024**) this may be contributed to the bone type in the mandible which is highly compact than cancellous bone in the maxilla and this is supported by Sthita [(15)].

In the present study, on the other hand, a significant increase in stability of angled DI was noted in the maxilla this may related to the high bone implant contact because the adequate available bone quantity in the maxilla than mandible which may be returned to the fact that of the resorption in mandible more than maxilla, in addition to that there was insufficient articles written about stability of both jaws.

In this research, there was a **significant increase** in the 2nd & 3rd values of total dental implants ISQ in patients aged **> 50** y**;** this may be related to that, the majority of patients was enrolled in this age group.

In addition to the stability was increased in patient > 50 in angled dental implants.

Clinical Analysis

Considering the clinical analysis one important point to be mentioned is that according to the **ISQ** device manufacturer that is based on more than 700 references, the ISQ values are divided into three levels **Andreotti *et al.*, 2017.**

1. **ISQ < 60** = low stability.
2. **ISQ 60-69 =** medium stability.
3. **ISQ ≥ 70** = high stability.

Accordingly, in the present research, a clinical analysis of the data is contemplated and performed by the researcher based on calculating the number of DI in which their ISQ values remained or changed to a different level when compared to the baseline data. The results were considered clinically significant or not, dependent on the number of DI that resided in the same level of ISQ or changed to another level regarding the 2nd and 3rd measurements compared with primary stability. This clinical analysis of data illustrated and confirmed that not all the statistically significant results essentially being clinically relevant as follows:

The statistical analysis reported a **significant increase** in the 2nd measurement in the age group **>50 y** and an increase in the 3rd one in the same age group of **males**. While, the clinical analysis demonstrated **no significant** change in age group **> 50** y (15 out of 16 DI resided in the same level).

In spite of that, the statistical analysis reported a **significant increase** in stability of dental implants in relation to males in regards to the total, axial and angled DI implants (**P= 0.000, 0.001&0.002)** respectively, and the mandible showed non-significant change in relation to any site and angle.

The clinical analysis using **McNemar test** demonstrated non-significant change in both genders in relation to different site and angles (P=1).

The patients >50y showed statically a significant change in total DI stability (P= **0.000)** while clinically there was non-significant change (P= 1).

Regarding the angles, the statistical analysis was reported a significant change in axial and angled DI stability, however it was clinically irrelevant.

The stability of total DI of the mandible, tilted implant in maxilla and angled 30º inserted dental implants presented with statistically significant changes (P= **0.024,040, 0.026 & 0.040)** respectively, in spite of that there was no clinical relevant in relation to that (P=1,0.25&1).

Conclusion

All-on-4–style full-arch dental implant procedures have one of the highest success rates of any treatment in dental treatments; the technique is also among the most difficult and can be fraught with obstacles. With careful planning and knowledge of potential pitfalls associated with performing, the procedure clinicians can incorporate All-on-4–style dental implant treatment into their practices with a high degree of confidence and less stress.

Survival rate if DI was 95.24% and patients benefited from the use of the All-on-4 treatment concept. The present study showed good clinical outcomes when using two tilted and two axial implants and a fixed prosthesis for rehabilitation of the edentulous ridges. The DI stability had significant effect in mandible in comparison to maxilla.

Declarations

Conflict of Interest the authors declare that there are no potential conflicts of interest related to the study.

Source of Funding: Nil

Ethical Clearance: This research has exemption as it a routine treatment (no new materials were used).

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