

## ORIGINAL ARTICLES

### Immediate Replacement of Agenic Lateral Incisors Using One-piece Mini and Midi Dental Implants

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#### ABSTRACT

This study evaluated the clinical success of OsteoCare™ Mini and Midi one-piece dental implants in restoring agenic maxillary lateral incisors. Fourteen implants were placed in nine patients both males and females with a mean age 21 years using the transmucosal flapless surgical approach and the immediate loading protocol. The ridge width at the missing teeth ranged between 4 mm and 5.5 mm as measured with a bone caliper. The patients were evaluated at the third and sixth month postoperatively. The clinical criteria to be checked were survival rate, osseointegration using the Periotest M and radiographic marginal bone loss. All the implants were successfully osseointegrated with a survival rate of 100%. Both the Mini and Midi implants showed a mean marginal bone loss of  $0.71 \pm 0.26$  mm at the third month and at the sixth month period the mean marginal bone loss was  $0.77 \pm 0.27$  mm. The mean Periotest M values were -2.3 and -2.4 at the third and sixth month respectively showing no statistically significant difference. The study revealed that the use of single-stage one-piece implant placement, immediate loading, and flapless surgery resulted in high success and survival rates. In conclusion, the use of the Mini and Midi one-piece dental implants is a valid, unique and simple treatment modality that is capable of providing optimum esthetics and function in patient with atrophic ridges.

**Key words:** Replacement, Agenic laterals, Dental Implants.

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#### Introduction

Tooth agenesis is the most commonly occurring developmental anomaly of the human dentition. It is present in almost 25% of the population (Garib *et al.*, 2005). Maxillary lateral incisors are the third most frequent agenic teeth after third molars and lower second premolars (Krassnig and Fickl, 2011). Females were found to be slightly more affected as compared with males. The incidence of agenic maxillary lateral incisors has been reported to range between 1-2 % and even higher reaching 5% (Graber, *et al.*, 2005). Agenic maxillary lateral incisors pose a difficult esthetic and treatment planning problem for clinicians. Age, location, space limitations, alveolar ridge deficiencies, uneven gingival margins, occlusion and periodontal factors often necessitate an interdisciplinary approach.

Treatment options include orthodontic movement of canines into lateral incisor positions (canine substitution), prosthodontic restorations including fixed and removable prostheses, resin-bonded retainers, autotransplantation as well as single tooth implant placement (Krassnig and Fickl, 2011).

Dental implants have become widely accepted for the anterior maxillary single-tooth replacement. Successful functional and esthetic results require knowledge of various concepts and techniques of implant placement. An interdisciplinary team approach is necessary to provide the most predictable treatment outcomes since most of the patients with agenic lateral incisors need reconstruction of their malocclusion by the orthodontic treatment before implant insertion to assure that occlusal and restorative goals are met. The cooperative efforts of the orthodontist with the implantologist in treatment planning are crucial to offer the patient the best results. The orthodontist's role is to assure that suitable dimensions (mesiodistal width and vertical height) for implant insertion are created by proper orthodontic alignment of the teeth. Adequate space between the canines and central incisors, in addition to presence of sufficient bone width and height of the alveolar ridge where the implants will be placed should be available. For conventional implant placement, a parallel to slightly divergent orientation should be obtained between the roots of the central incisor and the canine. There should be at least 2 mm distance between the implant and the adjacent teeth and at least 5-6 mm space at the edentulous area for the crown. Also damage to the root structures of adjacent teeth during the orthodontic correction should be avoided (Gumus *et al.*, 2008 and Krassnig and Fickl, 2011).

Conventional multistage approaches for implant placement have been proven successful which contributed to the wide acceptance of implant dentistry as a treatment option. A healing time after tooth extraction before implant insertion was recommended, followed by another submerged and unloaded period before final restoration insertion. This was designed to eliminate implant micromovements following surgery, which was thought to likely result in either failure of osseointegration or fibrous tissue encapsulation of the implant (Bidez and Misch, 1992). Yet innovative implant procedures often enable clinicians to achieve function, esthetics and comfort with utilizing a minimally invasive surgical approach (Panduric *et al.*, 2008).

Improvements in surgical techniques and implant designs have enhanced primary stability of implants, increasing the acceptance of modifying the loading protocols for single implant crowns. Various clinical reports on the use of immediate / early loading protocols on different clinical situations have been published and reviewed documenting the successful use of this approach (Zahran *et al.*, 2010 a; Zahran *et al.*, 2010 b and Boedeker *et al.*, 2011). Immediate loading of dental implants makes it possible to give the patient an esthetic appearance during the whole treatment period (Panduric *et al.*, 2008). Several studies have shown that immediately loaded single implants in the anterior region were having the advantages of shortened treatment time in addition to optimization of esthetics and function, with high recorded success and survival rates (Andersen *et al.*, 2002 and Zahran *et al.*, 2010 a).

However, only few case reports were found on the use of dental implants to treat agenic maxillary lateral incisors (Strong 2008 and Winkler *et al.*, 2008) and none of them evaluated the use of immediate loading protocol using the narrow diameter dental implants.

The aim of the present study is to evaluate the clinical success of the transmucosal flapless implant placement and immediate loading of the OsteoCare™ Mini and Midi one-piece implants to restore the agenic lateral incisors after completing the orthodontic treatment and during the retention period.

## **Materials and Methods**

### *Patient's selection:*

Nine patients (3 males and 6 females) were included in this study with a mean age 21 years. The age of males ranged between 19 and 23 years (mean = 21 years). While the age of the females was between 19 and 21 years (mean = 20 years). All patients had one or two agenic maxillary lateral incisors. All subjects included were in good general health, and had no condition that might contraindicate implant placement. Criteria for exclusion from the study were: 1) Patients with history of systemic disease, drug abuse, catabolic drug or psychiatric disorder; 2) Patients having insufficient bone quantity and quality and also insufficient vertical inter-arch space upon centric occlusion; 3) Patients in the growth stage with partially erupted teeth; 4) Patients with parafunctional habits such as bruxism or clenching that might produce overload on the placed implants; 5) Patients having deep buccal concavity; 6) Patients having vital anatomical structures in proximity to the proposed implant site; 7) Heavy smokers and alcoholics were also excluded.

All patients participated in the study were thoroughly informed about the treatment planning including the surgical protocol and all the risks associated with the procedures and signed an informed consent form.

### *Treatment Planning:*

After obtaining the history a full set of orthodontic records including radiographs, models and clinical photographs were taken to confirm the diagnosis of the agenic laterals and to plan the preprosthetic orthodontic alignment. Participating clinicians determined the patient's treatment plan collaboratively and communicated throughout the course of the treatment to ensure that all aspects are considered and that the overall treatment objectives are achieved. The orthodontist's role was to assure that the needed space (mesiodistal and vertical dimensions) is attained at the root for the implant insertion and at the crown for the final restorative element to be placed. All patients received oral hygiene instructions and periodontal treatment (full mouth scaling and root planning) before starting the treatment procedures or during the treatment period whenever needed.

### *Orthodontic treatment:*

The goal of orthodontic alignment was to achieve sufficient bone at the future implant site between the neighboring teeth roots to place the implant. The roots of the central incisor and canine were placed parallel or slightly divergent to avoid complications resulting from root proximity. A distance of 1 mm between the Mini or the Midi implant and the adjacent teeth was required and at least 5-6 mm space for the crowns to be placed was created (Gumus *et al.*, 2008 and Krassnig and Fickl, 2011). Esthetics and occlusion were considered in the final orthodontic positioning of the teeth adjacent to the edentulous space.

*Presurgical assessment:*

Clinical local visual examination and palpation to examine the entire oral and para-oral tissues at the future implant site was carried out. Also the interarch space was evaluated clinically. Radiographic re-evaluation of the standardized periapical and panoramic radiographs previously performed was done and used to measure the residual bone height and to confirm the absence of any clinically undetectable pathology. Maxillary and mandibular impressions were made and poured into study casts. The ridge width at the future implant site was evaluated through the diagnostic casts or directly in the patient's mouth using graduated bone caliper before using the tissue punch. The ridge widths of all the cases were atrophic and ranged between 4 mm to 5.5 mm. Study casts were mounted on a semi-adjustable articulator to evaluate the inter-maxillary arch space, type of occlusion and direction of forces with respect to the future implant site.

*Implant selection:*

In the present study fourteen OsteoCare™ Mini and Midi one-piece implants (OsteoCare™ Implant System, London, United Kingdom) were placed in nine patients both males and females as shown in table (1).

Six Mini implants with the diameter of 2.8 mm were used to restore cases with a ridge width of 4 to 4.5 mm while eight Midi implants with the diameter of 3.3 mm were used to restore cases with a ridge width of 4.5 to 5.5 mm. Both the Mini and Midi one-piece dental implants are designed to allow immediate loading in healed bony sites which allow for simultaneous expansion and compression of the bone improving the bone quality and overall width. They can be placed with a minimally invasive transmucosal flapless procedure as they possess a tapered pointed tip. These dental implants are machined from titanium alloy to provide maximum strength and incorporate both the implant body and the integral fixed abutment in a single component. They are grit-blasted and acid-etched, with a high load 'buttress' thread design that allows maximum bone to implant contact, resulting in high stability even in poor quality bone. The tapered design of the implants allows the placement in atrophic ridges as well as in limited tooth to tooth spacing.

**Table 1:** The number, type, diameter and length of the used implants.

Patient no.	Patient age	Gender	Implant	Diameter	Length
1	23	male	Midi	3.3mm	16mm
2	23	male	Midi	3.3mm	13mm
3	21	male	Midi	3.3mm	13mm
			Mini	2.8mm	13mm
4	20	female	Midi	3.3mm	13mm
			Mini	2.8mm	13mm
5	21	female	Midi	3.3mm	13mm
			Midi	3.3mm	13mm
6	19	female	Mini	2.8mm	13mm
			Mini	2.8mm	13mm
7	20	female	Mini	2.8mm	13mm
			Mini	2.8mm	13mm
8	20	female	Midi	3.3mm	13mm
9	21	female	Midi	3.3mm	13mm

*Surgical procedures:*

The surgery started by administration of local anesthesia followed by implant placement according to the manufacturer's directions. After using the tissue punch, a curette was used to remove the plug of soft tissue, exposing the bone. Osteotomy preparation was carried out utilizing the transmucosal flapless approach.

*Site preparation and implant placement:*

An ultra pilot drill (1.3 mm diameter) was used for the flapless transmucosal osteotomy preparation to give needlepoint accuracy for position, angle and depth. The depth of the osteotomy preparation was shorter than the implant length as the implant has strong self-tapping and self-drilling properties. The drills were mounted on a low speed hand-piece and copious saline irrigation was used as a coolant. After the osteotomy preparation, the implant was removed from its protective pouch and offered to the site. The implant was placed manually and rotated clockwise till resistance for seating was achieved. The 1.9 mm or the 2.4 mm overhex driver was connected to the ratchet wrench and used for complete seating of the implant. The first thread of the implant was placed 1-2 mm below the crestal bone level and was confirmed by taking a periapical radiograph. Primary stability of the implant was evaluated by using the torque wrench. Primary stability of over 30 N/cm was considered crucial to allow for the immediate loading protocol.

*Abutment preparation:*

Diamond or carbide high-speed burs were used to adjust the angulation and height of the abutment. The abutment preparation was carried out under a copious stream of water irrigation to prevent overheating.

*Provisional Restoration:*

Once the abutment preparation was completed, the provisional acrylic resin restoration was fabricated. It was important to have a smooth contour of the provisional restoration to avoid irritation of the soft tissue. The provisional acrylic resin restoration was then temporary cemented to the prepared abutment of the implant. The provisional crown was carefully adjusted out of direct occlusal contacts in centric and eccentric positions.

*Post-operative instructions:*

Oral hygiene instructions were given to the patients. No preoperative or postoperative antibiotics or analgesics were prescribed. The patients were instructed to resume their daily activities the day following the surgery. Strict instructions were given regarding diet; patients were instructed to avoid biting on hard food with the implants and to try to eat soft food during the first two months postoperatively. Finally, a standardized periapical radiograph was taken to check the final implant position and to estimate the initial bone level around the implant.

*Follow-up:*

The patients were examined and evaluated preoperatively, at three months and six months postoperatively. The clinical criteria to be checked were survival rate, Periotest M values and radiographic crestal bone level. Standardized panoramic and periapical radiographs were obtained at implant insertion and subsequently at three and six months postoperatively to evaluate the crestal bone loss. The latter was measured from the radiographs by the same digitized technique used by Yoo *et al.*, 2006 using the linear measurement system of Digora software (Orion Corporation, Sordex, Finland).

The Periotest M (Medizintechnik Gulden, Bensheim, Germany) was used to check the osseointegration evaluating the clinical stability. Periotest M values (PT) between (-8 and 0) were considered the ideal values that denote successful osseointegration. Discomfort, pain and tenderness were evaluated according to the signs and symptoms of the patients.

*Final restoration:*

After a healing period of six months, impressions were taken after removal of the provisional acrylic resin restorations to be replaced by definitive ceramometal or zirconium restorations.

*Statistical Analysis:*

The t-test was used to study the changes in mobility and crestal bone loss. Data were presented as mean  $\pm$  standard deviation (SD) values. The significance level was set at  $P \leq 0.05$ . Statistical analysis was performed with SPSS 16.0® (Statistical Package for Scientific Studies) for Windows.

*Results:*

Complete soft tissue healing was generally uneventful in all patients with no reported postoperative inconveniences during the six months follow-up period. All the fourteen implants were successfully osseointegrated and no failures were reported. Only very mild discomfort and pain were experienced by all patients during the first week after implant placement and minimal need for analgesics was reported. Discomfort disappeared after the first week in all patients. No postoperative swelling was reported by all patients.

After the three months postoperative follow-up period both the Mini and Midi implants showed a mean marginal bone loss of  $0.71 \pm 0.26$  (SD) mm with a minimum of 0.36 mm and a maximum of 1.22 mm. At the six months period the mean marginal bone loss was  $0.77 \pm 0.27$  (SD) mm with a minimum of 0.42 mm and a maximum of 1.28 mm showing no statistically significant difference along the treatment period with P value = 1.0000 at both the third and sixth months as shown in table (2).

**Table 2:** shows the marginal bone loss values along the follow-up period.

Follow-up period	Mean marginal bone loss $\pm$ SD	Maximum	Minimum
3 months	$0.71 \pm 0.26$	1.22	0.36
6 months	$0.77 \pm 0.27$	1.28	0.42

The Periotest M values at the three months period never exceeded a maximum of -0.2 and a minimum of -3.00 for all the implants. At 6 months the Periotest M values reached a maximum of -1.2 and a minimum of -3.6 for all the implants. The mean Periotest M value was  $-2.3 \pm 0.70$  at the third month and  $-2.4 \pm 0.70$  at the sixth month showing no statistically significant difference along the follow-up period with P value = 1.000 at both 3 and 6 months postoperatively as shown in table (3).

**Table 3:** shows Periotest M values along the follow-up period.

Follow-up period	Mean $\pm$ SD	Maximum	Minimum
3 months	$-2.3 \pm 0.70$	-0.2	-3.00
6 months	$-2.4 \pm 0.70$	-1.2	-3.6

**Case no.1:****Fig. 1:** showing agenic maxillary lateral incisor space.**Fig. 2:** showing the osteotomy preparation.**Fig. 3:** showing manual implant placement.



**Fig. 4:** showing implant placement using the ratchet wrench.



**Fig. 5:** showing immediate post-operative periapical radiograph with the implant in place.



**Fig. 6:** showing immediate loading using provisional acrylic resin crown.

**Case no.2:**



**Fig. 7:** showing the prepared abutment.



**Fig. 8:** showing final crown restoration six months post-operative.



**Fig. 9:** showing six month post-operative periapical radiograph of the implant.



**Fig. 10:** Schematic drawing of the implant position replacing agenetic maxillary lateral incisors.

**Case no. 3:**



**Fig. 11:** showing preoperative evaluation of the edentulous areas.



**Fig. 12:** showing preoperative periapical radiograph of the right side.



**Fig. 13:** showing preoperative periapical radiograph of the left side.



**Fig. 14:** showing the implants in place from a buccal view.



**Fig. 15:** showing the implants in place from a palatal view.



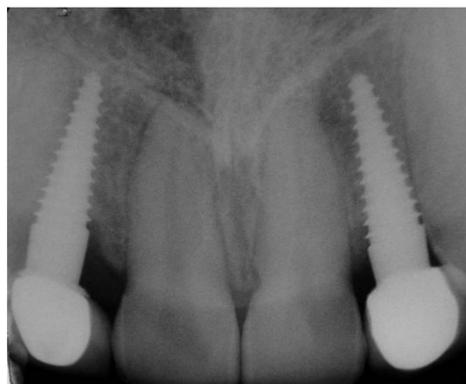
**Fig. 16:** showing the prepared abutments.



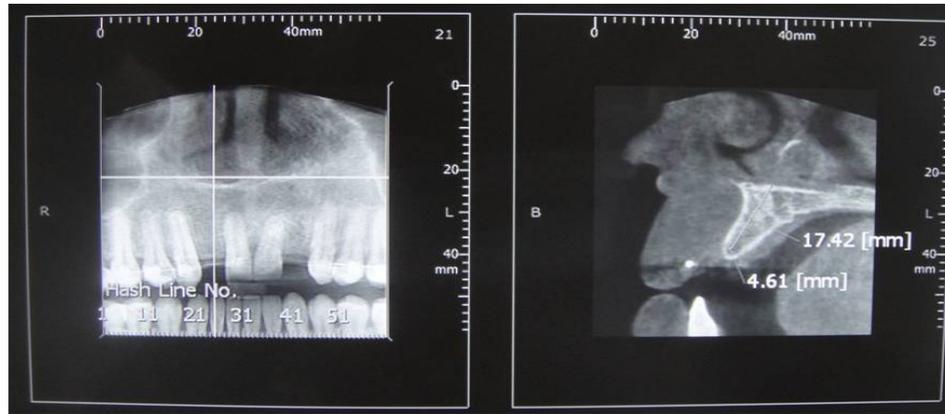
**Fig. 17:** showing final ceramo metal crowns six months postoperative.



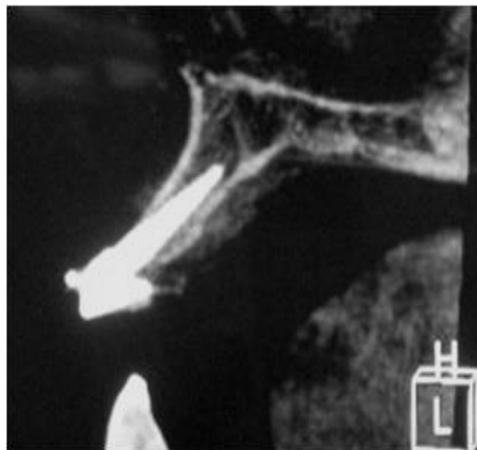
**Fig. 18:** showing the panoramic radiograph six months postoperatively.



**Fig. 19:** showing the periapical radiograph six months post-operatively.



**Fig. 20:** showing three dimensional (3D) CBCT (Cone Beam Computed Tomography) image for assessment in choosing the correct implant dimensions.



**Fig. 21:** showing sagittal cut from CBCT with the implant in place.

*Discussion:*

One of the most difficult areas for implant reconstruction has been the anterior maxilla, or what is known as the “esthetic zone”. Improved technology involving the surface of the implant body, abutment connection and prosthetic reconstruction of implants provided successful osseointegration with raised possibility of totally mimicking the esthetics and function of natural teeth at this area (Wheeler 2007). Proper selection of the patients, correct surgical techniques, suitable implant design, complete understanding of the concepts of occlusion, and the correct timing of implant placement are mandatory for optimum outcomes (Garg 2002). Bone growth with complete dentoalveolar and facial growth should be completed before implant insertion. It takes place in males around the age of 21 while in females it occurs at age of 16 years (Gumus *et al.*, 2008 and Kokich *et al.*, 2011). This coincides with the selected age range of the subjects included in this study. The females selected were older than 16 years while the males were between 21 and 23 years.

The conventional implant protocol advocate a two- stage technique for implant insertion followed by a load-free submerged healing period before restoration placement. Clinical research has now focused on reducing the treatment time, achieving optimum hard and soft tissue esthetics thus improving treatment outcomes. Using the full-thickness periosteal flap surgery is often accompanied by potential marginal bone loss and soft tissue recession, which are critical for single-unit implant supported restoration in the anterior maxilla, where the harmony of the soft and hard tissue architecture is of paramount importance to the development of natural esthetics and function (Kan *et al.*, 2000). Implant placement using minimally invasive one-stage flapless technique has a potential to minimize crestal bone loss, scar tissue formation, soft tissue inflammation, surgical time, and postoperative patient discomfort (Hahn 2000). The procedure is less time consuming, bleeding is minimal with no need to place or remove sutures (Panduric *et al.*, 2008). Leaving the periosteum intact on the

buccal and lingual aspects of the ridge maintains a better blood supply to the site, reducing the likelihood of resorption. Clinical conditions for using flapless approach consider a minimum of 5.0 mm keratinized tissue because the flapless procedure requires the actual removal of some of the tissue, and at least 4.5 mm of bone width must be available without undercuts of more than 15° (Hahn, 2000) which is in accordance with the present study in which the ridge width at the future implant site was between 4 and 5.5 mm.

The use of the minimally invasive one-stage flapless technique in the maxillary region with functional or non-functional immediate loading can shorten the treatment time and makes it possible to give the patient an esthetic appearance during the whole treatment period (Rocci, *et al.*, 2003).

Recent studies suggest that immediate restoration of single implants, after minimally invasive surgical approach, may be a viable treatment option.

There is substantial evidence that immediate loading of implants can be carried out without jeopardizing the survival rates, providing high initial stability of the implant and controlled loads (Romanos 2004 and Zahran 2008). In this study, the immediately loaded provisional restorations were kept out of occlusal stresses to avoid high magnitude of forces and cycles. This conservative approach of reducing stresses resulted in an enhanced outcome as previously documented by Gapski *et al.*, 2003.

The present study showed that the OsteoCare™ Midi and Mini one-piece implant design eliminated the manipulation of the soft tissue portion after initial healing period; therefore the need for placing healing collars or aesthetic abutments was avoided. The immediate construction and placement of provisional restorations after implant insertion, as done in the current study allow for better soft tissue adhesion and seal to form a healthy collar resembling that of a natural tooth. Also the easily prepared abutment part of the one-piece implant enables an individualized borderline of the preparation to exactly follow the contour of the gingival margin, without violating the soft tissue seal, potentially leading to better preserved interproximal bone and papillae yielding better esthetic results as previously documented by Hahn 2005.

It was reported that the control of micro-motion at bone-implant interface is probably the key for obtaining osseointegration in immediately loaded implants (Zahran, 2008). The implant-abutment junction in a two-piece implant design constitutes a structural weakness that may complicate the procedure (Hahn 2005). This was the cause for selecting the one-piece implant design in this study.

The OsteoCare's Mini and Midi dental implants used with the patients in the current study exhibit features that satisfy the immediate loading protocol demands. These one-piece conical implants are placed with undersized osteotomy preparation which allows the compression of the trabeculae of the spongy bone thus improving the implant initial stability and achieving a successful osseointegration even in poor bone quality since it can be placed in atrophic ridges. Also the special design of the buttress thread form of these implants has been shown to maximize bone-to-implant contact requiring only 1 mm space between the implant body and the root of the neighboring teeth. The use of titanium alloy-based implants in this study may be more advantageous than commercially pure titanium-based implants in reducing bending or fracture of the implants during the placement and function which was also recommended by Sohn 2002.

In their experimental work Jeong *et al.*, 2007 have found that the mean osseointegration and the mean peri-implant bone height were greater at flapless sites than at sites with flap concluding that the flapless surgery can achieve results superior to surgery with reflected flap. Becker *et al.*, 2006 have also confirmed that implants placed without flap reflection remained stable and exhibited clinically relevant osseointegration similar to when implants were placed using conventional flap procedures. These results are similar to those obtained in the current study since all implants used were successfully osseointegrated.

The overall survival rate attested in our study was 100% which conclude that the Mini and Midi implants yielded an excellent prognosis with stable bone levels and that free-handed flapless surgery is a viable alternative to more extensively planned guided surgery. This was also reported in a study conducted using the Midi implants which were immediately placed after extraction and immediately loaded showing a 100% clinical success rate (Zahran *et al.*, 2010 a). Survival rates in other reported studies, for flapless surgical approach, are between 91% and 98.7%, which indicate successful results of this technique application (Rocci, *et al.*, 2003; Becker *et al.*, 2005).

Another study using four to six Midi one-piece implants in the maxilla to support maxillary overdentures proved that it was ideal for most types of bone qualities, quantities and for atrophic ridges. The study reported that it is a reliable and cost effective treatment option that brings secure dentures within the reach of many patients, who are medically or financially compromised contributing to a higher degree of implant treatment acceptance due to less discomfort and generally shorter treatment times (Zahran *et al.*, 2010 b).

In the current study primary implant stability was confirmed by placement of torque values higher than 30 N/cm which is considered crucial for immediate loading. The grit-blasted and acid-etched surfaces of the used implants produce a defined micro-roughness. These rough surfaces offer a large contact area for maximum cell deposition to the implant. The surface microstructure that consists of micro- and macro-irregularities perfectly created by blasting and etching of the implant, increases the number of adhering osteoblasts enhancing the process of osseointegration as previously described by Misch *et al.*, 2004. Furthermore, the under- dimensioned

drilling using only one drill together with the bone condensing property of the used Midi and Mini implants in this study increased the initial stability. This was also confirmed by Sakoh *et al.*, 2006 who used conical shaped implants together with undersized form drill with the results showing achievement of high initial primary stability.

Absence of any signs of mobility throughout the evaluation period for the remaining implants demonstrated successful osseointegration which was confirmed by radiographs which did not show any peri-implant radiolucency around the evaluated implants. These findings were in agreement with Andersen *et al.*, 2002.

Soft tissue healing was generally uncomplicated in all patients included in this study. Only mild discomfort was experienced by all patients during the first week, which was attributed to the pressure resulting from bone expansion. All patients reported minimal postoperative swelling or pain experiences with no occurrence of hematoma and minimal need for analgesics. This aligns with previous results obtained by Azfar and Mark, 2006 and Zahran 2008 who concluded that the use of the flapless approach for implant placement minimized the post-operative pain and complications with maintenance of better blood supply to the marginal bone, thus reducing the likelihood of bone resorption (Becker *et al.*, 2005, Fortin *et al.*, 2006 and Zahran 2008).

Different studies recommended that placement of the implants should be done after completing the orthodontic treatment and ending the retention period in order to achieve soft and hard tissue stabilization (Krassnig and Fickl, 2011). This concept was in accordance with the current study.

#### Conclusion:

The OsteoCare's Mini and Midi one-piece implants provide excellent clinical performance with the immediate loading protocol. These implants have a number of characteristic features that set them apart from their conventional counterparts. They allow for atraumatic flapless transmucosal placement, as well as same day delivery of single or multiple tooth provisional restorations. They are considered an alternative to the conventional implant placement regimen and are ideal to be placed in varying bone qualities and quantities. They are capable of providing optimum esthetics and function with highly recorded success and survival rates.

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