

# CLINICAL EVALUATION OF SPLINTED VS. UNSPLINTED SHORT IMPLANTS STABILITY RETAINING MANDIBULAR OVERDENTURES

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## ABSTRACT:

**INTRODUCTION:** Short implants non-invasively tackles severely resorbed ridges. In mandibular overdentures, most literature considered splinting of short implants the safest option despite its complications. Therefore, unsplinted short implants is a promising alternative. The stability of implants given their short lengths is an issue that needs to be addressed.

**AIM OF THE STUDY:** Evaluate splinted and unsplinted short implant stability retaining mandibular overdentures in a one year follow-up. In addition, to evaluate the correlation between marginal bone loss and implant stability.

**MATERIALS AND METHODS:** 12 edentulous patients were included in the study and were divided into two groups (n=6), patients received mandibular overdentures. In the test group four short implants were kept unsplinted with ball and socket attachments, while in the control group four short splinted implants with a customized bar with ball attachments were used. Implants stability were evaluated at the time of implant placement and after one year of loading using a Resonance Frequency Analysis device. Marginal bone loss was measured on digital periapical x-rays at the one year mark to evaluate the correlation between bone loss and implant stability.

**RESULTS:** After one year, Implant Stability Quotient (ISQ) values were  $81.04 \pm 0.89$  and  $81.54 \pm 0.89$  for the test and control groups respectively, with no statistically significant differences. Marginal bone loss was  $0.97\text{mm} \pm 0.07$  with unsplinted implants, and  $0.92\text{mm} \pm 0.12$  with splinted implants. There was a negative correlation between implant stability and marginal bone loss.

**CONCLUSION:** Unsplinted short implants provide similar stability as splinted implants after retaining mandibular overdentures for one year.

**KEYWORDS:** Short implants, splinted, unsplinted, implant stability quotient (ISQ), marginal bone loss.

**RUNNING TITLE:** Unsplinted vs. splinted short implants stability in mandibular overdentures

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## INTRODUCTION

Edentulism is a debilitating condition that directly interferes with the patient's masticatory ability, speech and esthetics which in turn has a negative impact on the general and psychological health. Despite the reduction of its prevalence over the last ten years, edentulism is considered a major disease worldwide, as of 2016, it was reported that edentulism affected almost 10% of adults over 50 years (1).

been around for quite a long time, its quality is failing to meet the demands of patients with regards to sufficient retention and masticatory efficiency, especially in cases with flat alveolar ridges more oftenly found in the mandible. This is where osseointegrated implants play an important role, in fact, according to the McGill consensus statement in 2002, treating edentulous mandibles with two implant retained overdentures is considered the minimum standard of care (2).

Severe mandibular ridge atrophy has been an obstacle for safe placement of implants, as the presence of sufficient bone volume and quality is an essential prerequisite for implant placement. Overlooking this fact

has led to a wide array of complications ranging from simple failure of implants to complicated cases of permanent paresthesia, osteomyelitis and in severe cases mandibular fracture (3).

Different approaches have been described in literature to tackle the scarcity of bone in edentulous patients, these approaches are based on increasing bone volume with either bone augmentation or distraction osteogenesis, or are based on novel utilization of the remaining bone such as nerve transposition and the use of transmandibular implants or short implants. None of these alternatives is considered the gold standard for rehabilitation of an atrophic mandible. Each has its own specific advantages and disadvantages, including different morbidity, associated time and treatment costs (4).

The use of short implants (less than 8mm in length) simplifies treatment in a range of clinical situations, while reducing morbidity and economic cost. Moreover, extra short implants (less than 6mm in length) help meet the aims of contemporary implant dentistry; minimizing the invasiveness of procedures, and reducing

treatment time and economic cost while ensuring successful and predictable outcomes (5).

Traditionally, short implants supporting implant overdentures were either splinted to each other or to longer implants. Guljé et al (6) concluded that the one year survival rate of four 6 mm implants splinted with a bar and supporting a mandibular overdenture was 96% with high levels of patient satisfaction. In addition, Pimentel et al (7) underwent a photoelastic stress analysis on different lengths (5,7 and 9mm) and widths (4 and 5mm) of four implants splinted by a Chromium-Cobalt bar and concluded that although a decrease in length increases the stress around implants, an increase in width would cancel out the increase in stress leading to no difference between short and long implants.

Despite these findings, it has been shown that solitary attachments are less costly, less technique sensitive, and easier to clean than bars. Moreover, the potential for mucosal hyperplasia is more easily reduced with solitary ball attachments. In addition, from a clinical point of view, it is claimed that, resilient ball attachments allow for equal tissue and implant support which in turn protects the implants against overloading because most of the masticatory stresses are transmitted to the edentulous ridge (8).

Studies evaluating the use of unsplinted short implants in retaining overdentures are scarce and lack long term follow ups. El-helow and Monaem (9) evaluated the use of 6 and 8 unsplinted short implants (5-7mm in length) in retaining overdentures in severely resorbed mandibular edentulous ridges, reporting that no implants were lost after one year with a mean marginal bone loss (MBL) of 0.348mm to 0.357mm respectively.

An issue which may raise concern in unsplinted short implants is implant stability, although Calvo-guirado et al (10) evaluated insertion for extrashort implants (4mm in length) as an indication for primary implant stability, and found that there was no statistically significant difference between implants with lengths of 4mm and 10 mm, there are no studies evaluating the secondary or long-term implant stability in unsplinted short implants retaining mandibular overdentures.

Therefore, this clinical trial is aimed at evaluating short implant stability at the time of implant placement and after one year of function as compared to splinted implants and to determine whether stability is affected by marginal bone loss or not. The null hypothesis in this study is that there is no difference in short implant stability after one year of loading in both splinted and unsplinted cases.

## MATERIAL AND METHODS

This study was conducted in the Prosthodontics Department at the Faculty of Dentistry, Alexandria University after reviewing and approval from the ethical scientific research committee of Alexandria University, Egypt (IRB 00010556)-(IORG 0008839)/6-11-2016 and the implant's research committee. All aspects of the procedures performed including steps, follow up periods as well as possible complications and side effects were

clearly explained to the patients involved in the study and a written informed consent was obtained from each candidate. In addition, this clinical trial is registered at clinical trials.gov with identification number: NCT04582162.

Twelve edentulous patients with a maximum ridge height of 10 mm and a minimum width of 7 mm were included in the study, all patients were free from systemic diseases contradicting the use of implants, had class I ridge relations, adequate zone of keratinized mucosa and U shaped or square shaped arches. Heavy smokers, non-compliant patient based on their dental history and senile patients with impaired neuromuscular control were all excluded from the study.

All patients received four short Superline Denitum (Seoul, South Korea) in the parasymphiseal region using a flapless approach with the aid of a partially guided CAD/CAM surgical guide (Fig. 1a) along with the partially guided In2guide Universal surgical kit (Tustin CA, USA). Implants were 5.5mm in length and 5mm in diameter. Resonance frequency analysis (RFA) was utilized to measure the implant stability quotient (ISQ) using the Osstell device (Gothenburg, Sweden) (Fig. 1b), readings were recorded 3 times and an average was recorded for each implant.

Patients were then equally allocated into a test group where implants were kept unsplinted and a control group where implants were splinted, and an overdenture was constructed after two months following the delayed loading protocol. Patients were randomly allocated to either the test or control groups using a computer-generated list in a ratio of 1:1, the allocation sequence was concealed from the primary researcher in sequentially numbered, opaque and sealed envelopes.

In the test group, patients received Dentium mini ball stock abutments, they were secured on the implants using a torque wrench at 35 Ncm and impressions were taken to construct an acrylic denture in the conventional fashion. At the time of insertion, the abutment housings were picked up into the fitting surface of the denture using self-cure acrylic resin after blocking out undercuts in the ball abutments. (Fig. 2)

For the control group, impressions were recorded after implants were splinted using Duralay to ensure the passive fit of the bars. A customized bar was casted from wax with three Rhein83 (Bologna, Italy) OT Cap plastic patterns (Fig. 3) into Nickel-chromium alloy, their fit was evaluated using the Sheffield test clinically to ensure the passive fit of the bar (Fig. 4). After securing the bar on the implants, the steps were completed conventionally and housings were picked up into the fitting surface of the overdenture using self-cure acrylic resin after blocking out undercuts beneath the bar.

Dentures were delivered to the patients who were called up after a period of one year, marginal bone loss was recorded using digital periapical x-rays, to standardize the dimensions on the PA xray, a Dentsply XCP-DS fit universal sensor holder was used with an interocclusal index. (fig. 5) Osstell was used to record the ISQ values after unscrewing of the abutments and

bars, smart pegs of the Osstell were screwed on each implant, readings were also recorded three times for each implant and the mean was recorded.

*Statistical analysis:*

IBM SPSS software package version 25.0 (IBM Corp., Armonk, NY, USA) was used for statistical analysis. Quantitative variables were checked for normality using Shapiro Wilks tests, histograms and QQ plots. Independent t test was used to assess differences in ISQ values between both test and control groups, while paired t test was used to evaluate the difference within each group between the time of implant placement and the 12 months follow up. For evaluation of the correlation between bone loss and implant stability, Pearson correlation was used. The significance level was set at  $p < 0.05$ .

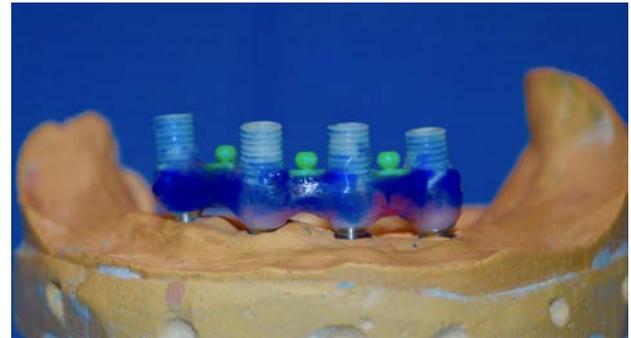
**Figure1:** a) Showing osteotomy preparation using partially guided CAD/CAM surgical guide  
b) Showing measuring ISQ using Osstell device at the time of implant placement



**Figure 2:** Showing intra-oral pick up of housing in patients with unsplinted implants



**Figure 3:** Showing wax pattern of customized bar with plastic Rhein83 OT caps



**Figure 4:** Showing Sheffield test evaluating fit of bar.



**Figure 5:** Showing XCP-DS fit universal sensor holder with an interocclusal index for standardization of Periapical x-rays.



**RESULTS**

A total of 48 implants were placed with a survival rate of 100%, survival representing no peri-implantitis, loss of osseointegration or mobility at the one year follow up mark. ISQ values were measured at the time of implant placement and after one year of loading to determine changes within each group and between both the test and control groups, in addition, marginal bone loss was recorded at the final follow up to determine correlation between bone loss and implant stability.

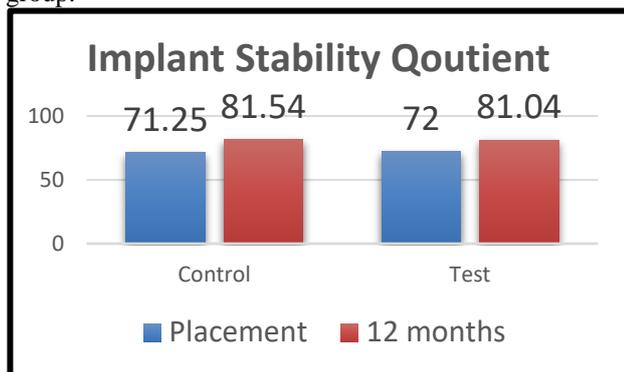
At the one year mark, although the marginal bone loss for the test group ( $0.97\text{mm} \pm 0.07$ ) was greater than the control group ( $0.92\text{mm} \pm 0.12$ ), there was no statistically significant difference ( $p=0.362$ ). (Table 1)

ISQ values at the time of implant placement and at the one year follow up are summarized in (Table 2 and Fig 6). The values recorded after one year showed a

statistically significant increase in both the test ( $p=0.002$ ) and control ( $p=0.001$ ) groups from the time the implants were placed. However, the difference between both groups was statistically insignificant ( $p=0.352$ ) recording  $81.04 \pm 0.89$  for the test group and  $81.54 \pm 0.89$  for the control group.

Table 3 demonstrates that there was a significant ( $p=0.017$ ) intermediate negative ( $r=-0.672$ ) correlation between mean marginal bone loss and ISQ values recorded at the one year follow up for both groups.

**Figure 6:** Showing ISQ values at time of implant placement and at one year follow up for test and control group.



**Table 1:** Showing marginal bone loss at the one year follow up

	Control (Splinted) n=6	Test (Unsplinted) n=6	T test value (p value)
<b>Bone loss at 12 months</b>	Mean (in millimeters) $\pm$ SD $0.92 \pm 0.12$	$0.97 \pm 0.07$	-0.96 (0.362)

**Table 2:** Showing ISQ values Showing ISQ values at time of implant placement and at the one year follow up for test and control group.

	Control (Splinted) n=6	Test (Unsplinted) n=6	T test value (p value)
<b>ISQ placement</b>	Mean $\pm$ SD $71.25 \pm 2.27$	$72 \pm 3.76$	-0.42 (0.685)
<b>ISQ 12 months</b>	$81.54 \pm 0.89$	$81.04 \pm 0.89$	0.98 (0.352)
<b>Mean difference (12 months from baseline)</b>	$10.29 \pm 1.91$	$9.04 \pm 3.88$	0.71 (0.495)
<b>Paired T test (p value)</b>	- <b>13.22 (&lt;0.001*)</b>	<b>-5.7 (0.002*)</b>	

**Table 3:** Showing correlation between marginal bone loss and ISQ values.

	n=12
r	-0.672
p	<b>0.017*</b>

r: Pearson's coefficient of correlation

**DISCUSSION**

Superline Dentium implants were selected for this study, these implants have all the criteria which make it a strong candidate for a good prognosis even in implants as short as 5.5mm in length, including platform switching which reduces marginal bone, as well as a tapered double threaded design with micro-craters and micro-pits which increases the implant's primary stability and increases the surface area to improve osseointegration, and finally an SLA surface which enhances its osseointegration capacity (11).

During the surgery, a partially guided surgical approach was preferred over a fully guided approach. This was because, the maximum width of the sleeve was 5mm to be compatible with the In2guide universal kit which meant that there was a risk of implant contamination if the implant width was 4.5mm or more. Moreover, the largest width of the guided universal kit drills was 4.3mm which meant that the final Dentium Superline drill was needed to finalize the osteotomy in implants greater than 5mm (12).

Implants of 5mm width were chosen for this study based on the finding by Himmlova et al (13) who confirmed through a finite element analysis, that increasing implant width is more important for dissipation of stresses, because the area receiving maximum effort is the bone crest and very little stress is transferred to the apical portion. Therefore, implant length may not be a primary factor in distributing prosthetic loads to the bone-implant interface.

Splinting implants is believed to prevent micro movements and non-axial load which enhances osseointegration and provides longevity to the implants, it also improves retention and stability of restorations which in turn leads to favorable force distribution and reduced residual bone resorption (14). However, bar retained/supported overdentures require more restorative space, are initially more expensive, are technically more complex, and require frequent activation of the clip (8). The prospect of using unsplinted short implants to retain overdentures was brought up due to the term known as secondary splinting, where splinting is achieved by use retentive attachments which are placed directly onto the implant, so the prosthesis itself provides splinting of the implants after seating (15).

Similar to the present study, El-helow and Monaem (9) evaluated the use of unsplinted short implants in retaining mandibular overdentures. Marginal bone loss reported in their study was lower than that observed in the current study after 1 year. This may be due to the fact that 6 and 8 implants were used in that

study as compared to only 4 short implants in the current study.

RFA is a noninvasive intraoral method which provides clinical evidence of implant stability. It involves sending magnetic pulses to a small metal peg attached on the implants, as the peg vibrates, the probe reads its resonance frequency and translates it into an ISQ value. Due to its high reliability, over the last two decades this method has gradually outperformed other techniques used to determine implant stability (16).

In this study, readings from the Osstell were obtained three times for each implant and the average was recorded to ensure repeatability and reliability of the recordings. This was opposed in literature as Herrero-Climent et al (17) concluded that one reading using the last generation Osstell with the smart peg was reliable enough although they recorded different values in different recordings. This was attributed to the tightening torque of the smart peg which is limited and may interfere with the accuracy of the readings.

At the time of implant placement, ISQ values were high indicating good primary stability due to the fact that surgical techniques nowadays surgical kits allow for drilling of undersized osteotomies which lead to high insertion torques (18). It has also been justified in literature that locking of implants is restricted to the superior cortical of the mandible, in which the bone is denser (19).

The significant increase in ISQ values recorded in the present study is in accordance with Alonso et al (20) who evaluated the primary and secondary stability of short single implants, this is an indication of successful osseointegration even after loading. According to the authors, bone quality was a more important variable affecting implant stability than the geometry of the implants.

Furthermore, ISQ values recorded during this study were similar to values recorded by Benlidayi et al (21) who registered a value of  $78.6 \pm 5.6$  after 12 months of loading. Moreover, Benlidayi et al also confirmed that there is no statistically significant differences in ISQ between short and standard implants.

Unlike the present study, Naert et al (22) concluded that ISQ values were in fact significantly greater in patients with two unsplinted implants with ball and socket attachments than in patients with two splinted implants with a bar attachment after 10 years of follow up. The difference in observations may be a result of comparing different types of attachments, where ball and sockets attachments allow for stress relieve around implants which is not the case in bar and clip attachments. This further explains the reason why in the present study there was no statistically significant differences between the two groups as the same attachment was used for both groups.

Finally, Monje et al (23) also agreed with the present study's finding that there is a negative correlation and that a decrease in one ISQ unit is related to almost 1 mm of MBL, and accordingly ISQ values may be used as an indicator for marginal bone loss.

This study confirms the null hypothesis in which there is no statistical significant difference in short implant stability after 1 year of loading in both splinted and unsplinted cases.

## CONCLUSIONS:

Within the limitations of the current study, the following can be concluded:

Short implants are an efficient short term (1 year) alternative for retaining overdentures in treating edentulous patients with severely resorbed mandibular ridges.

Using 4 unsplinted short implants to retain mandibular overdentures is accompanied with acceptable levels of marginal bone loss and implant stability as compared to splinting the implants.

## CONFLICT OF INTEREST:

The authors declare that they have no conflicts of interest.

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