Original Article

The Role of Minimally Traumatic Approach on Dental Implant, Stability and Bone Density-Comparative Clinical Study

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Abstract

Background: In traditional dental implant surgery, a sequential drilling strategy is used to ensure primary implant stability through press-fit. This technique may cause a certain degree of stress to the bone surrounding the implant. Other surgical procedures have been proposed. One of these methods involves implementing the Peripheral-Bone-Removal (PBR) protocol and relies on the morphological connection between the implant and the adjacent bone. This concept has been newly introduced. This approach is hypothesised to reduce bone damage and promote bone repair. The objective of this study is to investigate the impact of a minimally traumatic technique on both implant stability and bone density. **Methodology:** A total of twenty-five patients who met the inclusion criteria were assigned randomly to two groups. Group (A) consisted of 12 patients who received 50 IBS implants, while Group (B) consisted of 13 patients who received 50 Medentika implants. Both the primary stability and secondary stability were evaluated through clinical assessment. CBCT was used to measure both primary and secondary bone density for both systems before and 2 months after implant implantation. **Results:** The results of the Mann-Whitney Test indicate a highly significant difference in both primary and secondary bone density, as well as primary and secondary implant stability, for both dental implant systems (P=0.000). Group A exhibited significantly higher secondary stability compared to Group B (P=0.000). Group A implants exhibit a considerably greater amount of secondary bone density in comparison to Group B implants, as indicated by a P-value of 0.009. **Conclusion:** The use of the minimally invasive socket preparation technique, known as the PBR protocol, along with the morphologic contact concept, appears to enhance the success of dental implant treatment by improving bone quality and implant stability.

Keywords: Dental Implant, Peripheral Bone Removal Technique, Morphologic Contact, Dental Implant Stability, Bone Quality.

Introduction

A dental implant is an extremely effective procedure for replacing teeth that are missing.[1] Osseointegration is the fundamental basis for this achievement.[2] Osseointegration relies on various elements, with implant stability being one of them.[3] The stability of an implant is determined by various factors, including the mechanical qualities of the bone tissue, the maturity of the bone, the remodelling of the bone, the density of the bone, and the extent to which the implant is embedded in the bone.[4,5] This is demonstrated through two distinct phases: primary and secondary stability.[6]

The quality of bone healing, which is somewhat controlled by the dental implant design, is another element that affects osseointegration[7] and the extent of bone injury. Minimising mechanical and thermal bone stress is crucial while preparing the implant socket.[8] This establishes the basis for the sequential drilling protocol, which is widely used by most dental implant systems.

In the traditional method, primary implant stability is attained by a press-fit technique[9] where the dental implant serves as the ultimate drill. This approach involves applying gentle pressure to the surrounding

Access this article online

Quick Response Code:

Website: www.jnsbm.org

DOI: https://doi.org/10.4103/jnsbm.JNSBM_15_1_10

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Submitted: 16th March, 2024 **Received:** 17th March, 2024
Accepted: 01st April, 2024 **Published:** 16th April, 2024

How to cite this article: Alaridhy N J, Alhamdani F Y, Amor F B. The Role of Minimally Traumatic Approach on Dental Implant, Stability and Bone Density-Comparative Clinical Study. J Nat Sc Biol Med 2024;15:83-89

bone in order to securely attach the implant. The degree of involvement is quantified by the amount of rotational force used during insertion.[10]

A fresh concept has been developed that leverages the Peripheral Bone Removal (PBR) surgical procedure.[11] It creates a direct physical connection between the implant and the nearby bone. This method primarily depends on the implant thread to form a robust bond with the adjacent bone.[12]

The efficacy of this strategy has not been compared to the generally embraced conventional approach. The objective of this study is to assess the immediate treatment results of the PBR surgical procedure using a morphologic contact-based implant and sequential drilling surgery with a press-fit based implant.

Materials and Methods

The clinical investigation was conducted on patients who visited the Dental Implant Unit at the Diwanyia Secondary Dental Centre. Prior to the study, the goal of the research was clearly communicated to all participants and their agreement was obtained in writing.

The study recruited individuals with missing teeth in either the upper or lower jaw. Each patient's medical history was meticulously documented, followed by a comprehensive clinical examination of the oral cavity. A total of twenty-five patients who satisfied the specified criteria were assigned randomly to two separate groups. Group (A) consisted of 12 patients who received 50 IBS implants, while Group (B) consisted of 13 patients who received 50 Medentika implants.

Patients between the ages of 18 and 60 with one or more missing teeth meet the inclusion criteria. 2. Patients who are healthy in a systematic manner, 1. Sufficient bone height (greater than 10mm) and bone width (greater than 4mm) are required at the planned implant placement sites. 2. Patients must maintain good oral hygiene. 3. Patients should not smoke more than 10 cigarettes per day. 4. Patients with bone quality classified as Q2-Q3 (density ranging from 350-850 Hounsfield Units HU) are eligible. Exclusion criteria include patients with cardiac pacemakers, bleeding disorders, parafunctional habits such as bruxism, recent radiotherapy of the head and neck within the last six months, and a history of acute coronary heart attack within the past year.

Two dental implant systems were selected for the purpose of comparison. The initial system is the IBS system (Group A), which employs the PBR surgical process with an implant specifically tailored for morphologic contact. The second system is the Medentika dental implant systems, which belongs to Group B. The procedure utilises a traditional sequential drilling surgical process combined with a press-fit implant design.

The IBS implant features a root-shaped design and is equipped with a self-tapping fin thread. The Medentika implant system features a symmetrical conical design with a spiral-shaped triple-thread configuration. Additionally, the device features micro-rings located at the conical section to establish contact with the cortical plate. It also includes intermediate threads that curve towards the apex. To mitigate any potential bias, the first author conducted the Peripheral Bone Protocol by IBS Implants for the initial time. He lacks any previous familiarity with the system or the protocol. The study was carried out in the subsequent stages: 1. Assessment and strategizing for the placement and management of the implant. 2. Surgical procedure for Group A, 3. Surgical procedure for Group B, 4. Assessment before surgery, during surgery, and after surgery using clinical and radiographic techniques. 5. Gathering of data and statistical analysis of the findings. Comprehensive medical and dental history was obtained, and preoperative haematological studies were requested as necessary. Orthopantomogram (OPG) radiographs were obtained. Both preoperative and postoperative Cone beam CT (CBCT) scans were conducted to assess the density and volume of bone surrounding the dental implant (refer to Figure 1). A preoperative cone beam computed tomography (CBCT) scan was performed to assess the primary bone density at the planned implantation site. Postoperative cone beam computed tomographies (CBCTs) were performed three months following the surgery to quantify secondary bone density. Mean bone density values in Hounsfield units (HU) were utilised for this measurement.

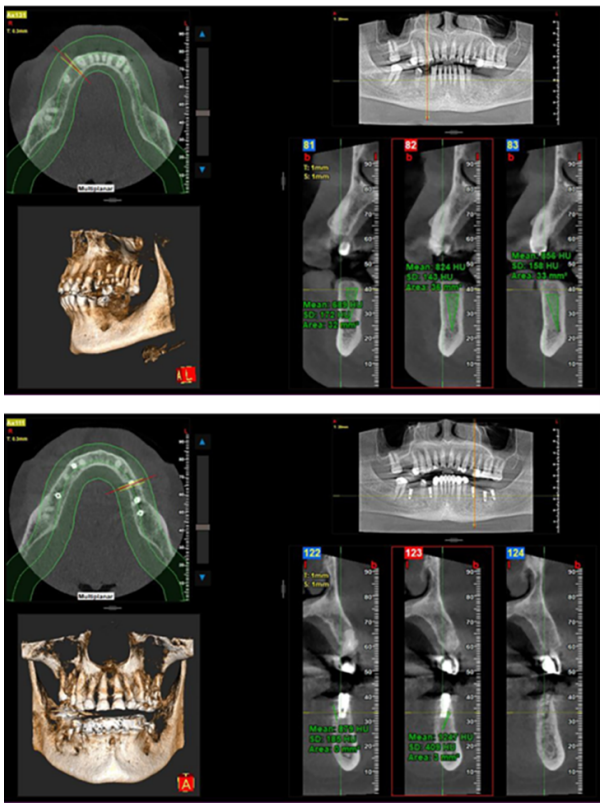

Figure 1: Preoperative (Upper View) and Postoperative (Lower View) CBCT for Both Lower First Premolar and Lower First Molar. They Provide the Pre and Postoperative Mean Bone Density Values in HU.

The surgical procedures were performed under stringent aseptic conditions. The surgery was conducted using local anaesthesia, specifically lignocaine at a concentration of 20 mg/ml with adrenaline at a ratio of 1:80,000. Upon attaining sufficient local anaesthesia. A surgical cut was made at the designated location for implant implantation using a No. 15 B.P. blade. A full-thickness mucoperiosteal flap was raised using a periosteal elevator.

An osteotomy was performed in accordance with the guidelines provided by the manufacturer. The Medentika dental implant was inserted using a sequential drilling technique, with abundant irrigation, until the desired osteotomy was attained. The implant was inserted into the prepared hole in the bone and positioned using a tool called a torque ratchet. The shoulder of the implant was positioned at the same level as the bone of the alveolar crest. Group A implants were drilled using a single drill process in accordance with the manufacturer's instructions. The torque required for inserting each implant was recorded. The stability of the implant was assessed using a resonance frequency analyzer (RFA) called OSSTELL Stampgatan®, which is from Sweden. In order to assess the stability of the implant, a sophisticated peg was affixed to the head of the implant. The transducer was positioned adjacent to the occlusal surfaces of the teeth, with a distance of only 0.5 to 1 mm from the smart peg (Figure 2). Measurements were collected many times in the mesiodistal and labiolingual directions, and the value that appeared most frequently was recorded. Following the procedure, the muco-periosteal flap was sealed using 3-0 black braided silk sutures in order to ensure immediate closure.

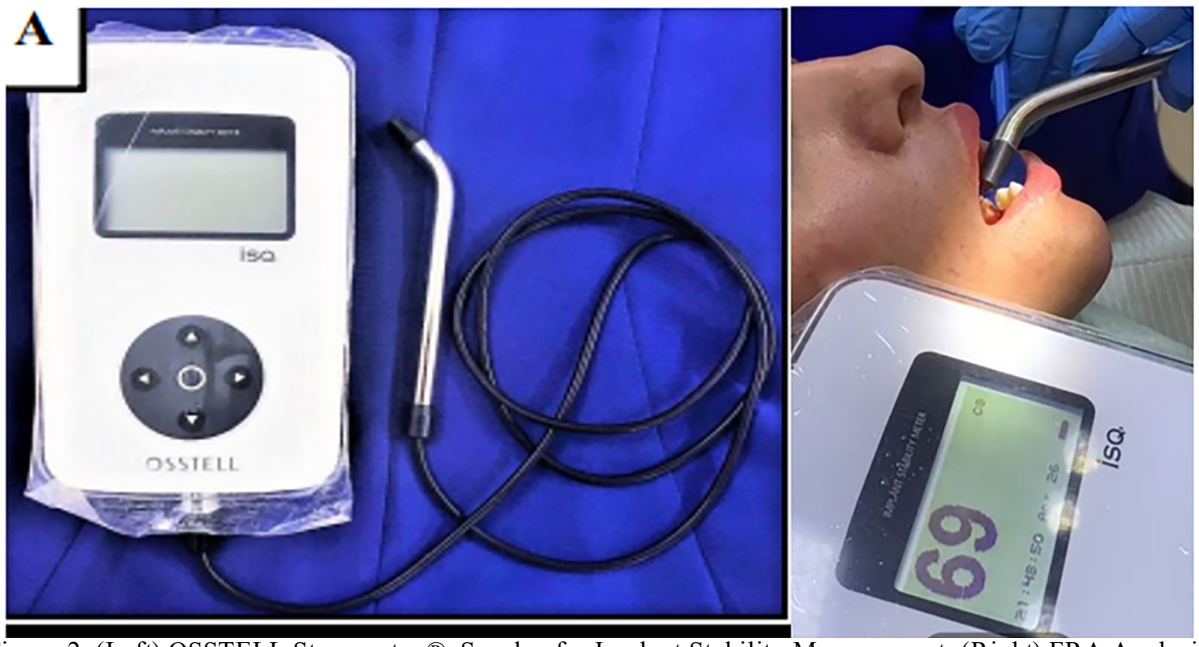

Figure 2: (Left) OSSTELL Stampgatan®, Sweden for Implant Stability Measurement, (Right) FRA Analysis for the Inserted Implant.

Patients were instructed to administer antibiotics and analgesics for a duration of 5 days following the surgery. Additionally, they were advised to use an oral mouth rinse containing Chlorhexidine Gluconate (0.2%) for a period of 15 days. The sutures were removed one week later. Regular intervals were used to review all the patients. Following a period of 3-4 months, a second-stage operation was performed to expose the implants. Subsequently, a gingival former was implanted and left in position for a duration of 15 days. The gingival former was extracted and the abutment was inserted.

Results

Although the lower age limit for inclusion into the study is 18 years, most of the patients included in the study were aged between 45–60 years. Mann-Whitney Test showed no statistically significant difference between both implant systems regarding patients' age (P=0.258). Eight males (30.4%) and 17 females (69.6%) participated in the study, with around a 2/1 ratio. Eleven patients, 8 females, 3 males) were treated with Medentika Implants. Fourteen patients (9 females, 5 males) were treated with IBS Implants. There was no statistically significant difference between both implant systems in relation to patients' gender (P=0.521, df=1)

Table 1 clearly illustrates that the majority of implants were placed to replace posterior teeth that were missing. A total of 48 implants, accounting for 48% of the total, were placed in the lower posterior region. This was followed by 39 implants, representing 39% of the total, in the higher posterior region. A total of nine implants, accounting for 9% of the total, were placed in the aesthetic zone. Additionally, four implants, representing 4% of the total, were inserted in the lower anterior zone.

Table 1: Implant Insertion by Tooth Position.

Implant Location Cation	No	%
11	1	1.0
13	2	2.0
14	5	5.0
15	2	2.0
16	8	8.0
21	2	2.0
22	1	1.0
23	3	3.0
24	8	8.0
25	7	7.0
26	7	7.0
27	2	2.0
34	11	11.0
35	7	7.0
36	11	11.0
37	4	4.0
41	3	3.0
43	1	1.0
44	4	4.0
45	3	3.0
46	8	8.0
Total	100	100.0

Table 2 provides the descriptive statistics for both dental implants (total no=100). Only two dental lengths (9 and 11mm) were used for the IBS system, whereas Medentika dental implant length ranged from 9 to 13mm. Three diameters were used for both IBS and Medentika cases (from 3.5-4.5 mm, 3.8- 4.2 respectively). Mann-Whitney Test showed no significant difference between dental implant systems in terms of dental implant length and dental implant diameter (P=0.137, P=0.290 respectively). Insertion torque values for both systems were different. Mann-Whitney Test showed a statistical difference between the two systems in the insertion torque measurement (P=0.02). Pearson Correlation Test showed that there was no significant relationship between the insertion torque and both primary stability stability (*P*=0.917).

Table 2, also, shows close values of primary stability in both systems. This has been statistically confirmed (P=0.381). Expectedly, there was a noticeable improvement in implant stability and bone density for both dental implant systems. This has been statistically confirmed. Furthermore, the Mann-Whitney Test showed a highly significant difference between primary and secondary bone density and primary and secondary implant stability for both dental implant systems (*P*=0.000).

Table 2: Descriptive Statistics for Both Dental Implant Systems.

Study Variables	Group A (IBS)				Group B (Medentika)			
	Minimum	Maximum	Mean	Std. Deviation	Minimum	Maximum	Mean	Std. Deviation
Primary Density	428	875	641.88	131.054	485	874	620.3	94.491
Primary Stability	58	76	66.04	2.885	62	76	65.98	2.646
Secondary Density	596	1002	759.72	135.296	465	963	687.7	115.945
Secondary Stability	63	80	73.06	3.053	65	78	68.92	3.319
Insertion Torque	35	40	37.9	2.493	30	40	36.6	2.755
Implant Length	9	13	9.6	1.161	9	13	9.48	1.111
Implant Diameter	3.5	4.5	4.14	0.2483	3.8	4.2	4.096	1.2718
Valid N (listwise)	50				50			

Pearson Correlation found a significant relationship between primary stability and secondary stability in all dental implant cases (*P*=0.036).

However, the secondary stability of Group A was higher than Group B (see Figure). This has been statistically confirmed. Mann-Whitney Test showed highly significant difference (*P*=0.000) between Group A and Group B in terms of secondary implant stability (see Figure 3).

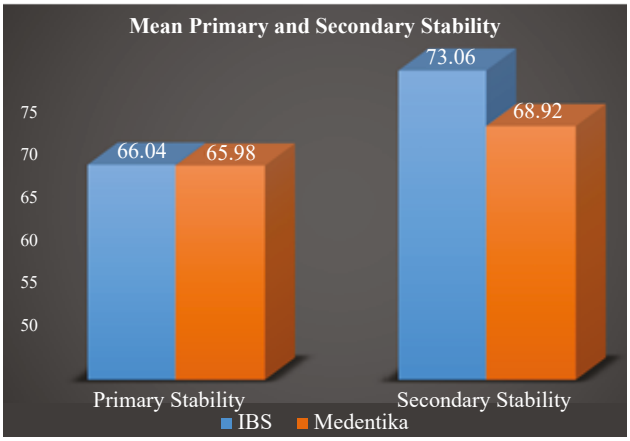

Figure 3: The Mean Values of Primary and Secondary Stabilities for Both Implant Systems.

In terms of bone density, IBS implants (Group A) have a significantly higher level of secondary bone density (P=0.009) compared to Medentika (see Figure 4). Pearson Correlation analysis showed a highly statistically significant relationship between secondary bone density and secondary implant stability (P=0.000).

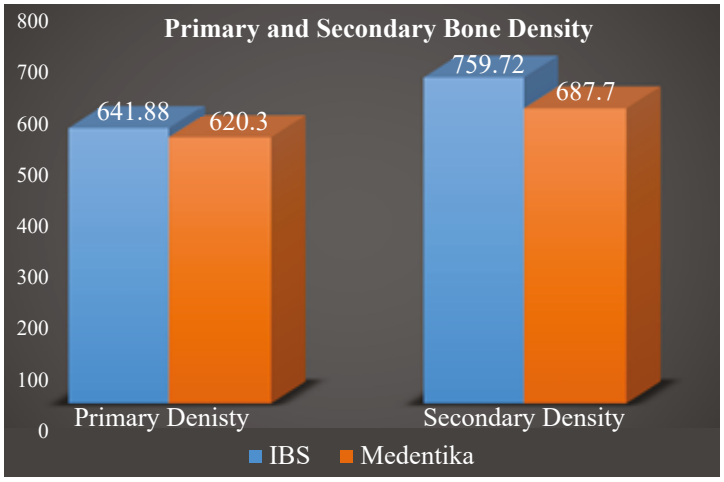

Figure 4: The Mean Values for Primary and Secondary Bone Densities for Both Implant.

Discussion

The age and gender of the patients in the current study were similar to those in prior investigations.[13] The majority of dental implants were placed in the posterior region of both the maxilla and mandible. This phenomenon has also been recorded in the literature.[14]

Implant insertion torque is believed to be an indicator of the level of mechanical attachment between the implant and the surrounding bone.[15] Nevertheless, this investigation indicates that it does not have an impact on the primary stability value. This phenomenon has been documented in previous research.[16,17] The absence of a correlation between insertion torque and primary stability measures may be due to the choice of measuring technique, specifically whether a mechanical or resonant frequency analysis method was used. The lack of distinction between both systems can be attributed to the consistency in bone quality, as no significant difference in primary density has been seen.

The notable enhancement in both bone density and implant stability in the two implant systems suggests that both dental implant systems successfully accomplished their immediate goals. The correlation between secondary bone density and secondary stability was evident, as anticipated. The secondary bone density is an indicator of the extent to which the bone has healed. It signifies accelerated bone regeneration.[18] This affects the secondary stability of the implant. Implant secondary stability is synonymous with biologic implant stability.[7] This correlation has been documented in various research investigations.[19]

Both the drilling process and implant design have the objective of minimising bone stress.[20,21] The IBS dental implant design minimises bone stress by exerting less pressure on the surrounding bone through the implant core. In addition, the implant's fin threads minimise bone chipping and decrease the shear strain experienced during the placement of the implant.[22] This has the potential to expedite osseointegration. This study has provided support for this claim through both clinical and radiographic evidence. CBCT imaging reveals that dental implants are associated with increased bone density, indicating a more rapid rate of bone repair. This is reinforced by the enhanced secondary stabilisation measures offered by IBS implants. The substantial enhancement of bone density in both systems following implant implantation implies a favourable outcome. Nevertheless, there are two primary distinctions between these systems. The initial distinction lies in the surgical protocol employed for the preparation of the implant socket. Medentika utilises the traditional sequential drilling methodology, while IBS depends on the single-drill peripheral bone removal (PBR) protocol. The latter appears to decrease the amount of mechanical surgical trauma by minimising the contact between the drill and the bone, hence reducing friction and saving time.[11]

Another distinction exists in the interaction between the implant and the bone. In an IBS implant, the implant body is not intended to be connected to the prepared bone. The principal stability mostly relies on the implant fin to achieve the morphological-contact idea. This reduces direct contact with the adjacent bone to a specific extent. This facilitates the process of contact osteogenesis. This is particularly effective in low-quality bone. Osteoprogenitor cells are able to directly generate bone on the surface of the implant.[23] In addition, the literature indicates that the use of a rectangular thread pattern is beneficial for enhancing the preservation of the bone between threads.[24] The fin thread design utilised by IBS implants seems to exploit this advantage by incorporating deeper threads and larger pitch regions.[25]

Unlike other dental implants, Medentika and most dental implants achieve main stability by applying precise pressure from the implant body and threads onto

the surrounding socket bone (known as press-fit)[9] to guarantee the requisite mechanical stability. Nevertheless, the bone that directly touches the surface of the implant has varying levels of resorption. Therefore, osteoprogenitor cells will primarily be sourced from the existing healthy bone in older individuals. This process is referred to as distant osteogenesis.[26]

The implant design minimises bone injury, leading to a more efficient and rapid recruitment of bone-forming cells from the adjacent healthy bone that is in direct touch with the implant surface.[23] This study provides an explanation for the increased bone density observed around dental implants in individuals with IBS, which subsequently leads to greater secondary stability.

As far as the authors are aware, this is the initial study that examines the differences between two ideas (minimally traumatic and traditional) regarding bone density and implant stability. In a recent clinical trial conducted by Alhamdani et al in 2023, the short-term outcome of the IBS Peripheral Bone Removal technique was compared with the typical sequential drilling protocol utilised by other systems. The researchers determined that the PBR procedure can be regarded as a successful alternative to the traditional treatment.[11]

The previous study primarily focused on the IBS system's usage of the Peripheral Bone Removal (PBR) methodology. They contended that using a single-drill approach reduces the amount of friction between the drilling instrument and the prepared bone socket. Various single-drill protocols have been recognised in the published literature.[27-29]

An inherent constraint of the study is its focus on the immediate result. Extended longitudinal trials with longer follow-up periods would yield more comprehensive understanding of the efficacy of both dental implant systems.

Conclusions

The utilisation of the minimally invasive socket preparation technique, namely the PBR protocol, along with the morphologic contact concept, appears to enhance the overall success of dental implant treatment by improving bone quality and implant durability.

Data Availability

Data available on request

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper."

Funding Statement

[no financial support was granted for this research paper]

Acknowledgments

The authors would like to thank both dental implant companies for making all the necessary equipment available for the research purpose

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