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CLINICAL AND RADIOGRAPHIC EVALUATION OF THE EFFECT OF IMPLANT THREAD DESIGN ON DENTAL IMPLANT EFFICACY

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ABSTRACT

Background: The main objective of the present study was to evaluate clinically and radiographically the effect of two dental implant thread designs on implant primary stability and efficacy. **Methods**: Twenty dental implant units (20 non-submerged tissue levels, simple line implants with two different thread designs) were inserted in 8 patients (4 males and 4 females) with an average age of years (ranged from 22 to 43 years) were included in this study. Patients were randomly divided in two equal groups: Group 1: Patients received implants with buttress shaped thread design. Group 2: Patients received implants with combination threaded square and v-shaped **Results**: After 6 months; Combination Square and V- shaped thread design group showed a statistically significant increase in Osstell measurements. After 6 months; there was a statistically significant difference between Modified plaque index measurements in the two groups. There was no statistically significant difference between Crestal bone losses in the two groups. **Conclusion**: The use of Combination Square and V- shaped thread designed implants did not differ significantly than the use of buttress shaped threaded implants, in terms of implant stability values as well as limitation of crestal resorption, usually seen after implant loading.

INTRODUCTION

As osseointegration has been considered a key prerequisite for the success of dental implant, the bone-to-implant contact rate is a standard quantitative parameter for an implant's successful healing and stability when implant healing is experimentally assessed. Thus, long-term success of an implant can be achieved by obtaining the primary stability of the implant to mechanical support through surrounding bone in early stage, as well as by osseointegration between the surrounding bone and implant, through bone regeneration and remodeling in the late stage(1). However, the effective bond between an implant and its surrounding bone is depending upon various mechanical factors.

One of the key factors is the implant design, since it determines primary stability and stress distribution during osseointegration. The geometric features of an implant can influence sufficient initial contact to facilitate primary stability of the implant. It, also, plays an important role on the implant capacity to withstand forces during osseointegration process. Therefore, the optimal implant design itself can improve the potential osseointegration process and the primary and secondary stability of the dental implant (2). Surface roughness has been considered as an important factor to obtain a good primary stability. In mechanical evaluation, dental implants having higher average roughness showed better primary stability than machined implants (3).

One of the proposed methods to increase primary stability, is to change the implant design; such as shape of the implant body and thread; length; or diameter. Various thread designs in tapered implants

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and various designs of dental implants reported to have an effect on primary stability. Thus, tapered implants showed higher primary stability than cylindrical implants [4]. In addition, thread depth showed a greater contribution than thread width to stress distribution to alveolar bone [5]. Titanium implants with a deeper thread depth provide a larger surface area and have an advantage in areas of poor-quality bone by increasing stability [6].

The type of force applied to the implant– bone interface may influence the degree and strength of osseointegration. Three types of loads are generated at the interface; compressive, tensile and shear forces. In squared and buttress threads, the axial load of these implants is mostly dissipated through compressive force thus lead to more bone deposition and increasing primary stability of dental implant [7]. Implants with V-shaped and buttress threads have been shown to generate forces which lead to bone defect formation. [8] Furthermore, square thread implants were found to have greater bone-to-implant contact (BIC) and higher reverse torque when compared with V-shaped and reverse buttress implants [9].

Lee et al performed a clinical study using similar implant type with and without micro threads on crestal modules and implants were placed in occlusion and showed that marginal bone loss was lower in the micro threaded group [10]. A clinical study using Variable threaded tapered implant under immediate loading and follow-up was made for 24-month post operatively was done. They concluded that variable thread tapered implant can be a safe and effective treatment option [11]. Another Clinical study was done using variable-thread tapered – NAI (Nobel Active internal connection), NAE (Nobel Active external connection) and Standard tapered – NR (Nobel Replace) applying immediate loading. Results showed that variable design showed comparable findings to those of standard tapered implants [12]. In view of these, it would be of interest to search for the possible effect of implant thread design on dental implant efficacy. Thus, this study was designed and performed in an attempt to clarify this aspect.

SUBJECTS AND METHODS

Twenty dental implant units (20 non-submerged tissue levels, simple line implants with two different thread designs) were inserted in 8 patients (4 males and 4 females) with an average age of years (ranged from 22 to 43 years) were included in this study. They were selected from the outpatient clinic of Department of Oral Medicine, Periodontology, Oral Diagnosis and Oral Radiology, Faculty of Dental Medicine (Boys – Cairo), Al-Azhar University.

Patients were randomly divided in two equal groups: Group 1: Patients received implants with buttress shaped thread design**.** Group 2: Patients received implants with combination threaded square and v-shaped. All subjects were received initial periodontal therapy consisted of prophylaxis, supra and subgingival scaling, subgingival debridement if needed, and polishing.

Preoperative assessment of all patients was carried out including history taking, clinical examination of Plaque and Gingival index and radiographic examination. Study casts were created for evaluation of edentulous areas and occlusion, cone beam computed tomography (CBCT) scans were done. The implants used in this study were between 3.2 to 5.2 mm in diameter, implant insertion was performed according to manufacturer's instructions.

Osstell device reading was carried out two directions perpendicular to long axis of implant and parallel to long axis of implant. Plaque index (PlI) and Sulcus Bleeding Index (BI) were recorded after 3, 6 and 9 months after surgery. Digital periapical x-ray has been carried out to evaluate crestal bone changes.

RESULTS

After 3 as well as 9 months; there was no statistically significant difference between Osstell measurements in the two groups. After 6 months; Combination Square and V- shaped thread design group showed a statistically significant increase in Osstell measurements. After 3, 6 as well as 9 months; there was no statistically significant difference between Peri implant pocket depth measurements in the two groups. After 3, 6 as well as 9 months; there was no statistically significant difference between Modified sulcular bleeding index measurements in the two groups. After 3 and 9 months; there was no statistically significant difference between Modified plaque index measurements in the two groups. After 6 months; there was a statistically significant difference between Modified plaque index measurements in the two groups. There was no statistically significant difference between Crestal bone losses in the two groups Table (1).

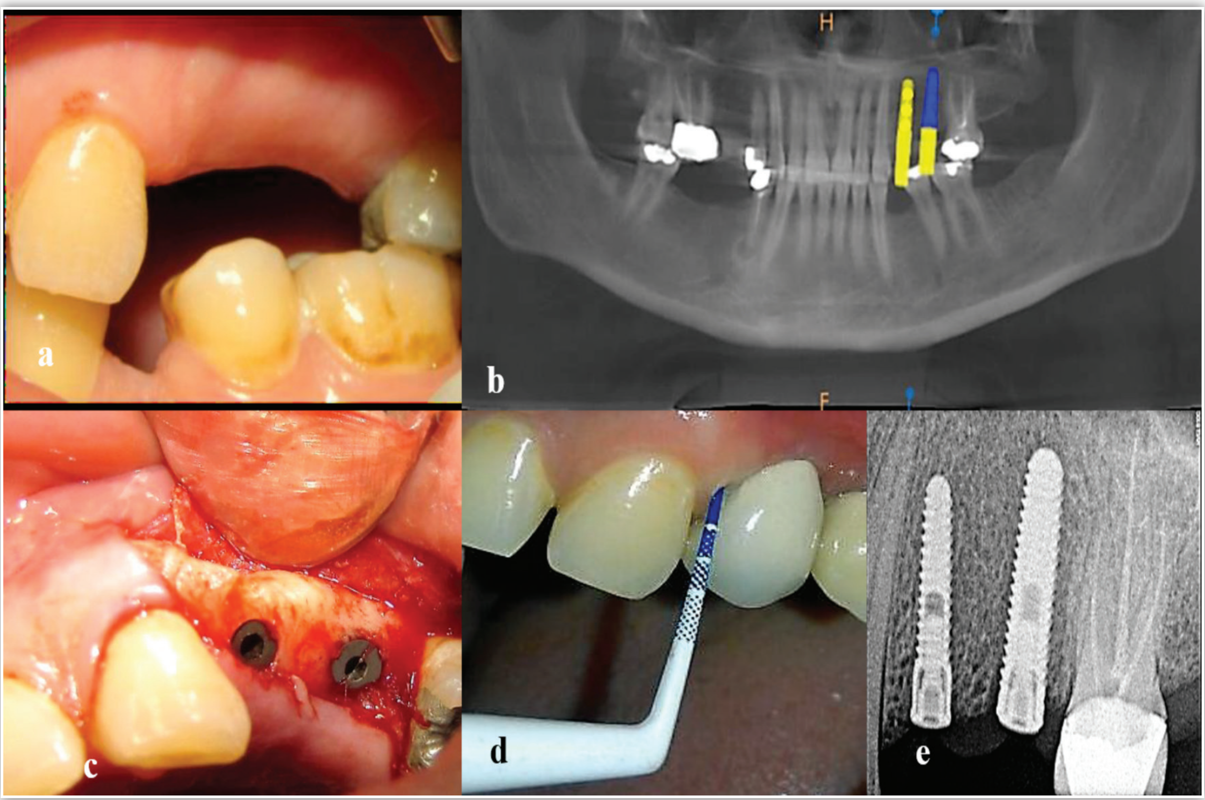

Fig. (1): a. Preoperative clinical photograph for edentulous sites, b. Virtual implant treatment plan, c. surgical procedures, implant insertion, d. peri-implant pocket depth using Kerr implant probe, and e. Radiographic follow.

TABLE (1): Comparison between the two groups according to Osstell, Peri implant pocket depth, Modified sulcular bleeding index, and Crestal bone loss.

Osstell	Buttress		Combination Square and V-shaped thread design		t	P
	Mean	±SD	Mean	±SD		
3 months	89.75	7.46	85.75	2.75	0.755	0.479
6 months	85.25	4.35	88.75	1.89	1.006	0.387
9 months	88.50	5.69	89.50	1.73	1.009	0.352
Peri implant pocket depth						
3 months	1.0	0.0	1.0	0.0	-	-
6 months	1.50	0.53	1.38	0.52	0.475	0.642
9 months	2.0	0.0	2.0	0.0	-	-
Modified sulcular bleeding index						
3 months	1.0	0.0	1.0	0.0	-	-
6 months	1.75	0.46	1.75	0.46	0.0	1.0
9 months	1.50	0.53	1.25	0.46	1.0	0.334
Modified plaque index						
3 months	0.75	0.46	1.0	0.0	1.528	0.170
6 months	2.25	0.46	1.50	0.53	3.0*	0.010*
9 months	1.0	0.0	1.25	0.46	1.528	0.170
Crestal bone loss	1.50	0.53	1.38	0.52	0.475	0.642

DISCUSSION

Nowadays, dental implants represent a reliable treatment option in oral rehabilitation of partially or fully edentulous patients in order to secure various kinds of prostheses. The long-term success of dental implants has been well established in the literature, and numerous investigators have documented the biological factors, surgical procedures, and restorative principles that influence the outcome of implant-supported restorations [13].

Osseointegration of dental implants was previously characterized as a structural and functional connection between newly formed bone and implant surface, which became a synonym for the biomechanical concept of secondary stability [14]. Secondary stability of a dental implant largely depends on the degree of new bone formation at the bone-to-implant interface [15]. Such bone-to-implant contact and is widely used in research to measure the degree of osseointegration [16]. The objective of the radiographic examination is to measure the height of bone adjacent to the implant(s) and to evaluate the presence and quality of bone along length of the implant, as well as to detect any peri-implant radiolucencies. Although the predictive value of assessing implant stability with radiographs is low, films offer a reasonable method to measure changes in bone levels. Periapical radiographs have excellent resolution and, when taken perpendicular to an implant, can provide valuable details of the implant-abutment junction, mesial and distal crestal bone level relative to the implant platform, and bone to implant interface along the length of the implant.

The limitation of periapical radiographs is that they are difficult to standardize, and great variability is inherent in acquisition process. However, periapical radiographs are relatively simple, inexpensive, and readily available in the dental office. It is diagnostically important to obtain images that clearly show implant threads and the restorative-implant abutment connection [17].

Threads are designed to maximize initial contact, enhance the surface area, and facilitate dissipation of loads at the bone-implant interface. Functional surface area per unit length of the implant may be modified by varying three geometric thread parameters thread pitch, thread shape, and thread depth [18]. Thread pitch is the distance measured parallel between adjacent thread form features of an implant. Distance from center of the thread to the center of next thread, measured parallel to the axis of a screw is defined as thread pitch [19]. The smaller or finer the pitch, the more threads on the implant body for a given unit length thus the greater surface area per unit length of the implant body if all other factors are equal. The thread pitch may be used to help resist the forces in poorer quality bone. Therefore, if force magnitude is increased, implant length decreased or bone density decreased, the thread pitch may be decreased to increase the thread number and increase the functional surface area. Thread depth is the distance between the major and minor diameter from the tip of thread to the body. The conventional implant provides a uniform thread depth throughout the length of the implant; greater the thread depth, greater the surface area of the implant if all other factors are equal. Hence, thread pitch and thread depth were standardized and kept constant.

The thread shape is another characteristic of overall thread geometry. The thread shape in dental implant designs include square, V-shaped, buttress, and reverse buttress thread designs. The square or power thread provides an optimized surface area for intrusive, compressive load transmission. Most automobile jacks or engineering designs built to bear a load use some form of square design [20]. In conventional engineering applications, the V-thread design is called a fixture and is primarily used for fixating metal parts together. The reverse buttress thread shape was initially designed for pull-out loads of the foundation. It was reported in the literature that stress (compressive) was more evenly distributed in the case when implant thread shape was square. It was demonstrated that superiority of square thread configuration as it showed the lowest stresses for all degrees of osseointegration in the implant-cortical bone transition region of the square threads. Hence, this study does not consider the square thread and evaluates V-thread, buttress, and reverse buttress thread designs. Buttress and reverse buttress thread designs dissipate the stress transfer pathway from a single high-stress area into numerous disconnected areas of bone near the thread's tips. Reasons for it being the stress concentration yielded by geometric discontinuity and stress shielding effect. The geometric discontinuity of the threaded designs results in high stress at the valley between the thread pitches. High stress in buttress and reverse type of thread designs is primarily transferred through the implant surface of the valley of the thread reducing the stress in the bone near the interface which may improve osseointegration and benefit the threaded implants with greater bone-implant contact. Thread designs such as reverse buttress, which showed more compressive stresses, may be considered for bone stimulation [21].

Implant design features are one of the most fundamental elements that have an effect on implant primary stability and implant ability to sustain loading during or after osseointegration. In this respect, two types of the implant design; macro design and micro design are known. The former includes thread geometry and body shape while the latter consists of implant material, surface treatment and morphology [6]. Macro design includes thread, body shape and thread design (e.g., thread geometry, face angle, thread pitch, thread depth (height), thickness (width) or thread helix angle). Micro design constitutes implant materials, surface morphology and surface coating [22]. Thread geometry is one of the effective factors of assessing primary stability and osseointegration.

Steigenga et al used Rabbit's tibia with different implant threads (square thread, V-shaped and reverse buttress) in natural bone cortical and cancellous and non-intentional loading and reported that square-thread design achieved greater bone implant contact [9]. In addition, V-thread, thin thread, two square threads of 0.24 mm and 0.36 mm thread widths after applying 141 N oblique loads at 45° were analyzed and the results showed that V-thread and thick square thread had significantly less in cancellous bone. Fifty-five dental implants with trapezoidal thread; buttress thread, square thread, and standard V-thread were tested using 300 N axial loads and it was reported that micromotion was located near the interface of cortical and cancellous bone. The study showed that implant with a square thread profile might provide the best primary stability under immediate loading [23].

The FEA was performed by Kong et al. in 2006 for V-threaded implant with pitches from 0.5 to 1.6 mm. Axial and bucco-lingual load were applied resulting in decreased stress with lowering pitch from 1.6 mm up to 0.8 mm. Thread pitch with less than 0.8 mm showed more stress. Thread pitch affects stress more significantly in cancellous bone. A study was done in sheep iliac crest using implants with narrow-pitch implant thread pitch, wide-pitch implant thread pitch and it was concluded after 8 weeks of loading that increasing the implant surface area by using implants with smaller pitch might be beneficial to improve primary stability in cancellous bone [24].

It should be emphasized that, a study was performed on 53 patients selected to receive implant with micro threads up to the prosthetic platform after immediate loading and follow-up for 3-year concluded that the implant system used in this study had 100% survival rate and minimal marginal bone loss. The locations of micro threads played an important role in the stabilization process [25]. A clinical study has been done using implant group with square thread with a wide pitch thread pattern of 1.2 mm and other implant group with V-shaped threads with a narrow pitch thread pattern of 0.8 mm. The results of this study showed that tapered implants with a wide pitch thread pattern and square thread geometry achieved greater primary stability values than cylindrical implants, with a narrow pitch thread pattern and V-shaped thread geometry measured with Insertion torque value. The square thread shape can be a more important feature than the number of threads to obtain acceptable implant stability values [26].

In the present study twenty implants were inserted in eight patients: ten implants with buttress thread design and the other ten implants had combination square and v-shaped thread design. These implants were clinically and radiographically evaluated, to examine crestal bone behavior with both types of implants. Clinical evaluation was carried out using peri-implant pocket depth, plaque index and sulcus bleeding index. Radiographic evaluation was carried out using digital periapical radiographs at baseline, 6 months and 9 months after implants insertion. The results using Osstell showed the mean Osstell in the Buttress group was of 89.75 ± 7.46 after 3 months, 85.25± 4.35 after 6 months and 88.50± 5.69 after 9 months. While mean Osstell of Combination Square and V- shaped thread design group was 85.75 ± 2.75 after 3 months, 88.75 ± 1.89 after 6 months and 89.50 ± 1.73 after 9 months. After 3 as well as 9 months; there was no statistically significant difference between the two implant thread designs. After 6 months; Combination Square and V- shaped thread design group showed increased measurements of Osstell.

Results of the present study showed no statistically significant difference between crestal bone losses in the two studied groups; this finding is similar to those findings previously reported [27]. However, as a scanty research was performed in this regard, it seems likely that a firm conclusion requires more studies in an attempt to clarify this aspect as well as to improve our understanding of this point. Hence, depending upon the available bone, the thread design can be chosen. Different implant thread forms can produce different stress intensities at the bone structure. Cortical bone and bone structure adjacent to the first thread bears most of the von Mises stresses. Thus, it may be reasonable to suggest that in case of good density bone a threaded implant may be considered. If the bone quality is poor than the thread design which will promote compressive stresses and minimize von Mises stress as inferred the reverse buttress thread design can be chosen for better results.

CONCLUSION

The use of Combination Square and V- shaped thread designed implants did not differ significantly than the use of buttress shaped threaded implants, in terms of implant stability values as well as limitation of crestal resorption, usually seen after implant loading.

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