

COMPARISON BETWEEN CYLINDER AND TAPERED IMPLANTS IN DELAYED IMMEDIATE PLACEMENT

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ABSTRACT

Background: Implant geometry has a major impact on insertion torque values and primary stability, and bone engagement during implant insertion differs according to implant morphology.

Objective: This study was aimed to compare the implant survival and success as outcome of 2 types of implant morphology either the tapered or cylinder form in delayed immediate placement of dental implant.

Materials and methods: A total of 20 implants (10 for tapered and 10 for cylinder implants) were inserted after tooth extraction i.e. delayed immediate implant placement. The primary stability of each implant was measured by using insertion torque value. Then, implant examined clinically and radiographically for success criteria after placement.

Results: The insertion torque measurement was showed 38.50 ± 4.74 Ncm as a mean value for the tapered implant and 26.0 ± 5.16 Ncm for cylinder implant while the insertion time for tapered was 0.71 ± 0.07 second/mm and for cylinder was 0.95 ± 0.14 second/mm.

Conclusion: Tapered implants showed better primary stability than straight-walled implants and had a higher success rate. A higher insertion torque can lead to the destruction of peri-implant bone, compromising osseointegration and failure of dental implant.

Key words: Primary stability, insertion torque, delayed-immediate.

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INTRODUCTION

Implant geometry and design is one of the main features in implant success, concerning both body and the collar of an implant. Diverse implant designs are available; each one is advocated for improving bone to implant contact and reducing crestal bone resorption by minimizing biomechanical stresses to the bone (1,2).

There are two major design concepts: cylindrical and tapered, they differ in the healing sequence that follows the implantation (2).

Tapered, root form implants, generates an intimate contact between the osteotomy wall and the implant surface. The tight contact provides excellent primary stability but undergoes localized bone necrosis near the implant surface before bone apposition ensures its biomechanical fixation (2,3).

Cylindrical implants, parallel wall, tend to be less stable at implantation but gain stability rapidly, due to early formation of woven bone following the blood clotted gap between the implant and osteotomy wall (3).

One of the reasons that implant geometry keeps evolving is to obtain primary stability in fresh extraction sockets. This method known as immediate placement, a technique meant for shortening the period from an extraction of a tooth until final restoration can be provided, sparing both time and surgical procedures (4).

The anatomic characteristics of the socket after tooth extraction are different from the socket environment after proper healing. Implants placed immediately into fresh extraction sites engage precisely prepared bony walls only in their apex, due to the funnel shape of the socket, whereas the coronal space is filled only by the end of the healing phase (5).

From a biomechanical point of view the tapered geometry diverts forces from the dense cortical bone to the resilient trabecular bone, leading to higher forces in the apex, a desirable virtue in respect of immediate placement (2).

Cylindrical implant distributed force load throughout the implant and because of the parallel walls the coronal part of the osteotomy will be damaged by the preceding implant threads, making a cylindrical implant less suited for immediate placement (6).

The ideal timing of implant placement after dental extraction has been extensively discussed in the literature, and advantages and disadvantages have been attributed to the different protocols (7-9), although there is an increasing interest for shortening the overall treatment time and minimizing the number of surgical interventions.(7)

Late implant placement following extraction, with a healing period of 6–12 months prior to implant placement has been traditionally considered the standard of care, because a fully healed ridge will ensure implant insertion in a stable ridge dimension, but the bone availability for implant placement may have been hampered by the resorptive changes occurring in the ridge after tooth extraction.(8)

To overcome these potential drawbacks, different alternative approaches have been proposed, such as immediate implant placement at the time of extraction or early implant placement following a few weeks of soft tissue healing prior to implant insertion.(9)

At a recent consensus workshop (8,10), three different protocols were defined:

- (i) Type I or immediate when the implants are placed in the same surgical intervention as the dental extraction;

- (ii) Type 2 or early implant placement when implants are placed in the early stages of healing (from 4 to 8 weeks); and
- (iii) Type 3 or delayed implant placement when implants are placed when the ridge has healed (from 3 to 6 months)

The immediate implant placement may be adversely affected by the presence of infection (11) and lack of soft tissue closure and flap dehiscence over the extraction site, (12), particularly when barrier membranes have been used for guided bone regeneration (13-15). To overcome the problems of immediate implantation, alternative techniques have been described, calling for implant placement at various intervals following initiation of wound healing subsequent to tooth extraction (13,15).

The insertion torque is a surgical indicator of rotational resistance, during implant setting. Excessive insertion torque results in the undesired heat, surrounding bone ischemia, delayed bone healing, and even implant failure (16).

The primary stability is a structural indicator to denote the implant's immovability, immediately upon implantation (17).

In a recent in vitro study, Trisi et al (18) examined the relationships among primary stability, insertion torque, and bone density in straight-walled implants; they found a significant correlation between peak insertion torque and implant micromotion and significant differences in hard and medium bone compared to soft bone. Because implant geometry is believed to play a major role in insertion torque values, (19) clinical protocols that combine suitable implant morphology with torque value recording are now commonly accepted.

Therefore, this study was conducted to compare the success criteria of tapered and cylinder implants clinically and radiographically as a basis for clinical comparison during delayed immediate implant placement.

MATERIALS AND METHODS

This study was performed on sixteen patients of both sexes (10 females and 6 males). The age of the patients ranged from 20 -40 years. The patients were divided into two groups:

Group I: included 10 tapered implants and group II: included 10 cylinder implants.

The patients were selected from the Out Patient Clinic of the Oral & Maxillofacial Surgery Department, Faculty of Dentistry, Alexandria University. The patients' selection based on certain inclusion and exclusion criteria.

The inclusion criteria included that patients have one or more missing teeth in either upper or lower posterior region that were extracted 2 weeks to less than 3 months earlier (delayed immediate placement), sufficient bone volume, no evidence of periapical lesions and good oral hygiene. While exclusion criteria include esthetic reasons, extraction site healing of more than 3 months or less than 2 weeks, active periodontitis, residual roots in the implant site, mucosal diseases, current chemotherapy, indication for bone graft at the implant site, alcohol or drug abuse, smokers, systemic disorders, and pregnancy.

Informed consent

Patients were fully informed about the treatment procedures and follow up examination.. Appropriate institutional ethical clearance and written informed consent were obtained.

Implant system

The Dentium system implants (Superline tapered implants, Simpleline cylinder implants, Korea) with different diameters and lengths were used in this study .The surface of implants is sandblasting with large grit and acid etching.

Surgical procedure

Preoperative phase:

Before the extraction of the tooth to be restored by dental implant, radiographic examination by using periapical films or orthopantomograms to exclude any periapical infection. (Fig. 1a)

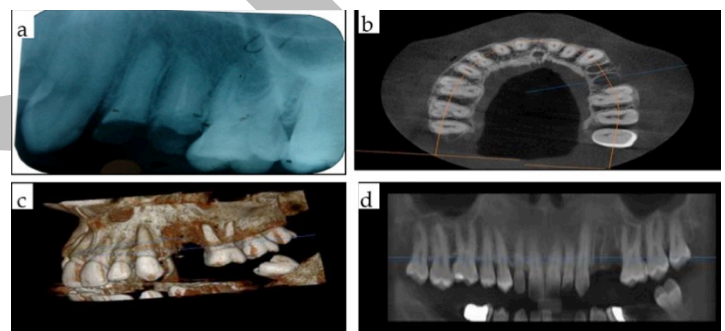


Fig. 1: (a) Preoperative periapical radiograph showing remaining roots of upper left premolars. (b) Preoperative CBCT radiograph showing axial section after 2 weeks of atraumatic extraction. (c) 3D view. (d) Panoramic view.

Then, clinical examination of extracted site after 2 weeks to start the surgery. Primary impression was taken and study model was casted.

Then, cone beam computed tomograph (CBCT) was done before surgery to visualize the available bone and surrounding anatomical structures. (Fig. 1b,c,d)

Operative phase:

With the patient under local anesthesia by using Mepecaine hydrochloride 2% (Mepecaine-L, Alexcopharma), an incision was made palatal to the crest of the ridge using bard parker blade #15 on the middle of the gingiva attached to the edentulous ridge and extended for several millimeters beyond the osteotomy area.(Fig-2a)

- a. Pre-surgical view of implant site after 2 weeks of extraction.
- b. After reflection of flap exposing extraction sites.
- c. Implant motors that used for implant placement and insertion torque measurement.
- d. Tapered implant preparation by drill.
- e. Tapered implant with hand piece before insertion.
- f. Insertion torque measurement by motor.
- g. Tapered implant after placement.

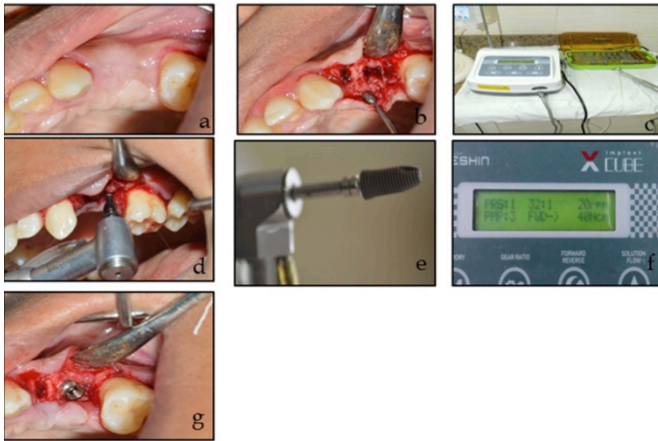


Fig. 2: A photograph showing the tapered implant placement and implant stability measurement.(Group I)

Full-thickness flaps were reflected exposing the alveolar ridge by using periosteal elevator with preservation of interdental papilla; the incision was made slightly lingual to the crest of the ridge for mandibular incision and palatal to ridge for maxillary incision. (Fig-2b)

The initial marking or preparation of the implant site was done with a pilot drill to establish the depth and align the implant in extracted site. A guide pin was placed in the osteotomy site to confirm the position and the angulations of the osteotomy. The osteotomy was then widened using intermediate drills and the final drill according to the diameter of the implant. (Fig-2d, 3a)

The implant was secured in its site by using the hand piece. (Fig-2e, 2g, 3b)

The cover screw was then placed. (Fig-3d) The flap was then sutured around the fixtures using 3/0 black silk suture.

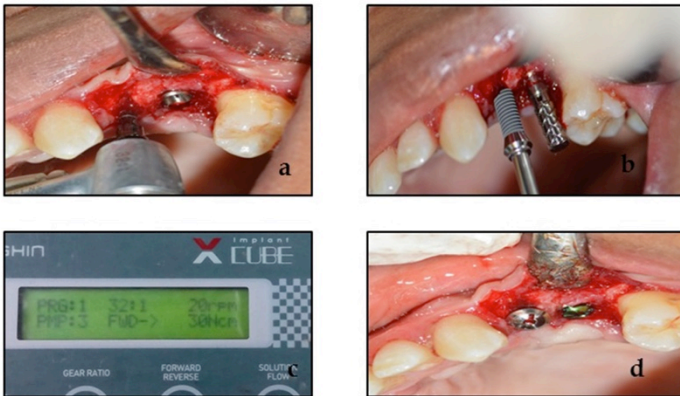


Fig. 3: A photograph showing the cylinder implant placement and implant stability measurement. (Group II)

- Cylinder implant preparation,
- Placement of cylinder implant by hand piece,
- Reading of motor during cylinder implant placement,
- Tapered and cylinder implants with cover caps.

Insertion torque measurement

During the implant insertion, the maximum insertion torque value was recorded by means of surgical motor (Dentium, Korea). (Fig-2c)

Starting from 20 Ncm, the placement torque was increased in steps of 5 Ncm, when the rotation stopped because of friction before the implant was fully inserted. The motor was developed to provide a well-controlled insertion torque to avoid mechanical overload of the equipment or bone tissue. The final maximum insertion torque value of each implant was recorded in Ncm. Then, the data would be subsequently processed to determine torque as a function of time. Before each implant was placed, the motor was calibrated and reset to a fixed insertion torque. (Fig.2f,3c)

Analysis were based on the evaluation of 1 mm of implant insertion, calculated as total implant insertion time/implant length (in millimeters), and the insertion times required for different implants were be compared.

Postoperative phase:

Postoperative instructions were given to the patients including: cold fomentation for the first 24 hours, warm mouth wash on the next day, oral hygiene recommendation by using Chlorhexidine mouth wash (Antiseptol 1%, Kahira) that started after the day of surgery 3 times daily for 7 days. Antibiotics for three days 3times daily by using Amoxicillian 500mg (E-mox 500mg cap, Eipico) was described. Non-steroidal anti-inflammatory drugs for three days 3 times daily by using Diclofenac potassium 50mg (Cataflam 50mg tablets, Novartis). The sutures were removed after one week post surgically.

Prosthetic phase:

After nearly 3 months for mandibular implant and 6 months for maxillary placement, the implant abutment and final prosthesis were placed (porcelain fused to metal).

Follow up period

Each patient was evaluated clinically and radiographically at intervals of 1,3,6,9 months.

Each patient was examined clinically for: pain, swelling, tenderness, gingival condition around the implant using the Løe and Silness Gingival Index (20), Per-implant probing depth using Glavind and Løe (21), and implant mobility was assessed according to McKinney and Koth (22).

Panoramic radiograph was used for comparison between two different forms of implants by evaluating position of the implant, bony density, osseointegration around implant and marginal bone level . (Fig.4)

The image calibrations and measurements were performed using image analysis software Image J version 1.43u. (Softonic International, S.A.)

The Statistical Analysis

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0 (Released 2011, Armonk, NY: IBM Corp). Quantitative data were described using minimum and maximum, mean and standard deviation and median.

The distributions of quantitative variables were tested for normality using Kolmogorov-Smirnov test, Shapiro-Wilk test and D'Agstino test. If it reveals normal data distribution, parametric tests was applied. If the data were abnormally distributed, non-parametric tests were used.

For normally distributed data, comparison between two groups were done using independent t-test while comparison between different periods using ANOVA with repeated measures and Post Hoc test was assessed using LSD. For abnormally distributed data, comparison between two groups were done using Mann Whitney test. To compare between the different periods Friedman test was applied and Wilcoxon signed ranks test. Significance of the obtained results was judged at the 5% level.

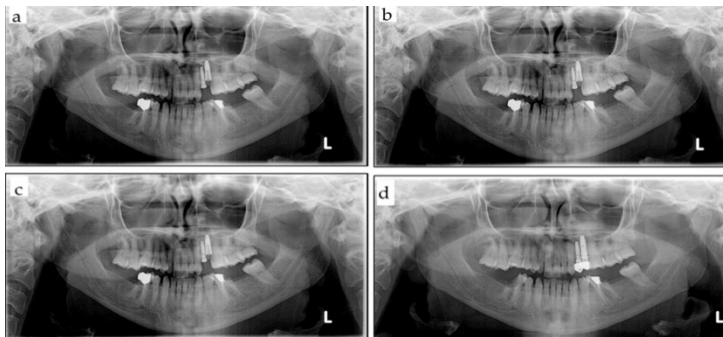


Fig. 4: Panoramic radiograph of the two implants taken (a) 1 month postoperatively (b) 3 months postoperatively (c) 6 month postoperatively and (d) 9 month postoperatively.

RESULTS

A total of 20 implants were placed in a total of 16 patients participated in this study, ranging in age from 20 to 40 years with mean age of (29.20 ± 4.98) years and both sexes (10 females and 6 males). Ten tapered implants were allocated in the group I with different diameters (3.4, 3.8, 4.3, 5 mm) and different lengths (8,10,12,14mm) in upper and lower posterior teeth (7 implant in maxillary posterior, 3 in mandibular teeth) Ten cylinder implants were allocated in the group II with different diameters (3.4, 3.8, 4.3, 4.8 mm) and different lengths (8,10, 12mm) in upper and lower posterior teeth (6 implant in maxillary posterior, 4 in mandibular teeth).

All patients had been operated under local anesthesia using surgical flap technique and implant placement, and no complications had been recorded during the operation.

The mean and standard deviation of insertion torque value and bone density were calculated for each group and compared to each other.

The insertion torque measurement showed 38.50 ± 4.74 Ncm as a mean value for the group I and 26.0 ± 5.16 Ncm for group II while the insertion time for group I was 0.71 ± 0.07 Second/mm and for group II was 0.95 ± 0.14 Second/mm. Therefore, group I had higher insertion torque and shorter time for insertion than group II. The difference was statistically significant. ($P < 0.001^*$) (Table 1, Fig.5)

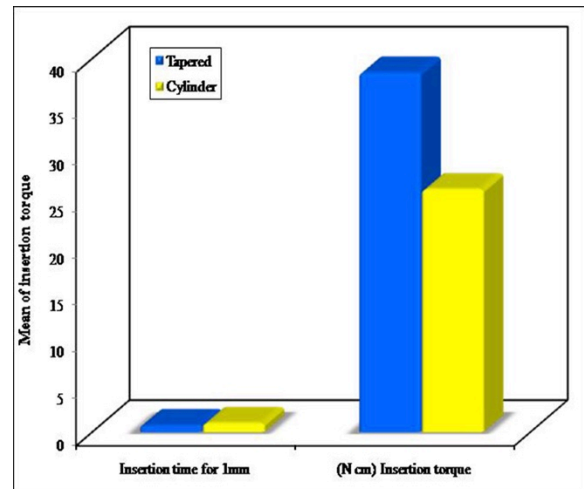


Fig. 5: Comparison between two studied groups according to insertion torque.

Table 1: Comparison between two studied groups according to insertion torque.

	Tapered (n=10)	Cylinder (n=10)	t	p
Insertion time for 1mm				
Min. – Max.	0.63 – 0.83	0.67 – 1.13		
Mean. \pm SD	0.71 ± 0.07	0.95 ± 0.14	4.923*	<0.001*
Median	0.71	0.96		
Insertion torque (N cm)				
Min. – Max.	30.0 – 45.0	20.0 – 35.0		
Mean. \pm SD	38.50 ± 4.74	26.0 ± 5.16	5.637*	<0.001*
Median	40.0	25.0		

t: Student t-test

*: Statistically significant at $p \leq 0.05$

All patients had been examined periodically during the follow-up period at 1,3,6,9 months postoperatively. Healing was uneventful in all cases with no post-operative complications except one case of group II.

One case of the group II was shown sign of failure that was severe mobility of implant clinically and radiolucent area around implant radiographically that was removed at end of the study.

Other clinical parameters had been recorded such as: Pain index, gingival index, implant mobility.

1- Pain, tenderness, infection or swelling; there was absence of pain and tenderness on the first postsurgical days during the follow up period. Post-operative edema and discomfort were very minimal and unobserved and no post-operative swelling, infection or nerve injury.

2- Gingival index (GI); the difference in the mean GI between these two groups was not significant throughout the study period. ($P=0.660, 0.498, 0.112, 0.317$ respectively)

3- Per-implant probing depth ; In the group I, the increase of the probing depth from the 1st month to the 9th month was

less than in the group II. The difference was not statistically significant at 1st and 3th. (P=0.673, 0.355 respectively) The difference became statistically significant at 6th and 9th. (P=0.001* 0.002* respectively)

4- Implant mobility ; only one case in group II was presented with visible severe horizontal mobility and visible vertical movement (Scale 4). All other cases presented with absence of mobility in all directions (Scale 0); to Slight detectable horizontal mobility (Scale 1).

5- The bone level changes were measured by using the Image J program. The mean value of the change in the marginal bone level was calculated and recorded on the 1st, 3rd, 6th and 9th months. The data collected was tabulated and the statistical analysis of marginal bone level scores was done for all patients. In group I, the marginal bone level decreased steadily from (1.42±0.13 mm) at 1st month to (1.27±0.17 mm) at 3rd month, and on the 6th month it was (1.01±0.31 mm) and on the 9th month it was (0.93 ± 0.37 mm). The decrease in the marginal bone level was statistically significant throughout the follow up period and the baseline. (p=0.001*, 0.001*, 0.003* respectively)

In group II, the marginal bone level increased steadily from 1st month (0.20±0.09 mm) to the 3rd month (0.23±0.12 mm), and on the 6th month it was (0.71±0.30 mm) and on the 9th month it was (1.18±0.53 mm). The increase in the marginal bone level from 1st with 6th was statistically not significant (p=0.167), while when compared between the 3rd, 6th and 9th month was statistically significant (p<0.001*, <0.001* respectively).

Comparing the marginal bone levels between the two groups, there was significant difference on the 1st, 3rd and 6th months. (p<0.001*, <0.001*, 0.040* respectively). There was statistically insignificant difference on the 9th month (p=0.219), while on the 6th month the difference was significant (p=0.033*). (Table 2, Fig.6)

Table 2: Comparison between two studied groups according to marginal bone level.

Bone level	1 month	3 month	6 month	9 month	F	p
Tapered						
Min. – Max.	1.27 – 1.65	1.01 – 1.54	0.56 – 1.61	0.53 – 1.72		
Mean. ± SD	1.43 ± 0.13	1.27 ± 0.17	1.01 ± 0.31	0.93 ± 0.37	13.250*	<0.001*
Median	1.44	1.27	1.05	0.80		
p		0.001*	0.001*	0.003*		
Cylinder						
Min. – Max.	0.12 – 0.35	0.13 – 0.44	0.21 – 1.25	0.28 – 2.37		
Mean. ± SD	0.20 ± 0.09	0.23 ± 0.12	0.71 ± 0.30	1.18 ± 0.53	37.261*	<0.001*
Median	0.16	0.18	0.64	1.11		
p		0.167	<0.001*	<0.001*		
t	25.084*	15.509*	2.213*	1.273		
p	<0.001*	<0.001*	0.040*	0.219		

t: Student t-test for comparing tapered and cylinder group
 F: F test (ANOVA) with repeated measures for comparing the four periods in each group
 p: for Post Hoc Test (LSD) for comparison between 1 month and each other period in each group
 *: Statistically significant at p ≤ 0.05

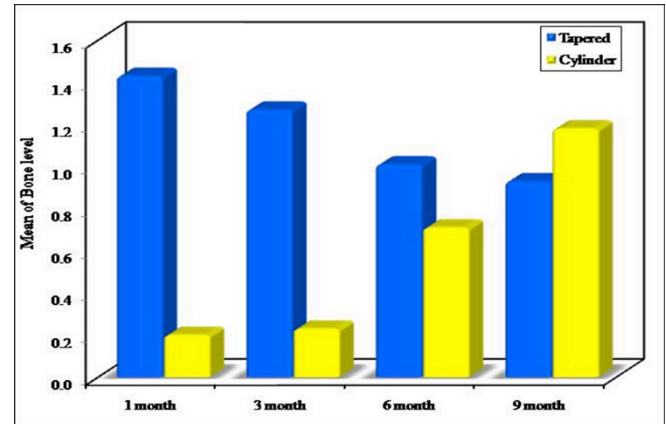


Fig. 6: Comparison between two studied groups according to marginal bone level

6- The bone density was measured on panoramic radiograph using also Image J program. The mean was calculated postoperatively, 1st, 3rd, 6th and 9th months post operatively and the increase in the bone density was significant throughout the follow up period except one patient in group II was presented with severe bone resorption around implant.

In group I, the marginal bone density increased steadily from 1st (72.71±9.69 mm) to the 3th month (91.18±18.62mm), and on the 6th month it was (127.13±20.80 mm) and on the 9th month it was (164.88±32.39 mm). The increase in the marginal bone density from 1st with 3rd, 6th and 9th month was statistically significant (p<0.001*, <0.001*, <0.001* respectively).

In group II, the marginal bone density increased from 1st (70.49±16.67 mm) to the 3th month (86.68±19.58mm), and on the 6th month it was (110.19±22.09 mm) and on the 9th month it was (144.27±38.53 mm) except one case shown severe bone resorption. The increase in the bone density was statically significant throughout the follow up period and the baseline. (p=0.004*, <0.001*, <0.001* respectively)

Comparing the bone density between the two groups, there was insignificant difference. (p=0.721, 0.605, 0.094, 0.165 respectively). (Table 3)

Table 3: Comparison between two studied groups according to bone density.

Bone density	1 month	3 month	6 month	9 month	F	p
Tapered						
Min. – Max.	60.82 – 87.47	68.84 – 120.48	89.70 – 157.10	105.83 – 183.5		
Mean. ± SD	72.71 ± 9.69	91.18 ± 18.62	127.13 ± 20.80	164.88 ± 23.39	93.670*	<0.001*
Median	72.04	87.96	135.11	173.77		
p		<0.001*	<0.001*	<0.001*		
Cylinder						
Min. – Max.	55.38 – 99.58	60.11 – 112.88	58.46 – 128.14	50.35 – 192.06		
Mean. ± SD	70.49 ± 16.67	86.68 ± 19.58	110.19 ± 22.09	144.27 ± 38.53	30.793*	<0.001*
Median	62.54	88.20	118.19	147.39		
p		0.004*	<0.001*	<0.001*		
t	0.364	0.526	1.766	1.446		
p	0.721	0.605	0.094	0.165		

t: Student t-test for comparing tapered and cylinder group
 F: F test (ANOVA) with repeated measures for comparing the four periods in each group
 p: for Post Hoc Test (LSD) for comparison between 1 month and each other period in each group
 *: Statistically significant at p ≤ 0.05

DISCUSSION

The primary stability is important factor for achievement of osseointegration (23-25) by preventing the formation of connective tissue in the implant / bone interface and allow the bone formation which allows appropriate distribution of masticatory functional loads (24,25).

Important strategies, such as increasing the quantity and quality of bone and appropriate implant designs have been investigated in order to provide the initial stability (25).

The present study was designed to compare implant success of two shapes of dental implants in delayed immediate placement by using insertion torque value to determine the difference between the primary stability of tapered and cylinder form of dental implant.

The primary implant stability was measured using insertion torque that was provided fast and objective information about the quality of local bone (25,26) and the primary stability at surgery (25). The widely used method described by Friberg et al.(27) to measure primary stability is insertion torque.

Our study used this method as standard analysis of primary stability, that it can be used to assess more accurately bone quality and support, which was measured at the time of final seating of the implant in the receptor bed (28,29).

Determining insertion torque is one of the most reliable (30) methods to obtain information about bone quality. Although insertion torque is proposed by many scholars, comparability among different implant systems is still unclear, and the minimum level of primary stability needed for immediate loading has not been defined (29,31).

The mean insertion torque value was 38.50 ± 4.74 for the group I while in the group II the mean was 26.0 ± 5.16 that values indicated a higher insertion torque in the tapered than that of cylinder implants. The mean time for insertion of 1mm of implants was 0.71 ± 0.07 S/mm for group I and 0.95 ± 0.14 S/mm for group II that meaning the tapered implant need less time for insertion than cylinder implant.

Javed and Romanos (32) found that the insertion torque of tapered implants is higher than that of straight implants. , the differences in insertion torque reflect different implant geometries, where cylindrical implants have a smaller primary stability than tapered ones. This behavior can be attributed to different thread shapes, implant geometries, and surface areas shows the implant thread geometries. The screw threads are different in cylindrical and tapered implants. The thread geometry of tapered implants leads to a larger surface area in contact with the host tissue (32).

In our study, the bone density in the group I increased steadily from 1st to the 9th month ,while in the group II, the bone density increased from 1st to the 3th month and then decreased on the 6th month and 9th and one case presented with severe bone resorption because low insertion torque at time of insertion and poor primary stability . The mean of bone density was increased in the group I than in the group II, so that more successful rate for tapered implants.

The insertion torque of tapered implant was higher than cylinder implant with less time for insertion so primary

stability of tapered implant was better than cylinder implant. The rate of success is higher in tapered implants.

This is in line with the finding of previous studies. The results of Degidi and Piattelli,(33) 2005, yielded 100% success with implants inserted with a torque higher than 40 N cm and loaded with provisional prostheses installed within 72 h following placement.

Rokn et al., (34) found that tapered implants exert more lateral compressive force on the bony walls surrounding the implant during implant placement. Therefore, in areas with inadequate bone height, where a short implant should be applied, the use of tapered implants is recommended.

On the other hand, some studies have reported results contrary to the results of the our study. In a study by Bilhan et al.,(35) cylindrical implants exhibited a higher resonance frequency analysis (RFA) compared to tapered implants, and so the success rate was 86% for tapered and 100% for straight-walled implants.(36)

CONCLUSIONS

The primary stability of tapered implant was higher than cylinder implant as tapered had higher insertion torque during placement and the insertion torque measurement was helpful for determine the primary stability of dental implants at time of placement.

CONFLICT OF INTEREST

Authors declared that there are no conflict of interest

REFERENCES

1. Huang HL, Chang CH, Hsu JT, Fallgatter AM, Ko CC. Comparison of implant body designs and threaded designs of dental implants: a 3-dimensional finite element analysis. *Int J Oral Maxillofac Implants.* 2007;22:551-62.
2. Morris HF, Ochi S, Crum P, Orenstein IH, Winkler SJ. AICRG, Part I: A 6-year multicentered, multidisciplinary clinical study of a new and innovative implant design. *Oral Implantol.* 2004;30:125-33.
3. Negri B, Calvo-Guirado JL, Maté Sánchez de Val JE, Delgado Ruiz RA, Ramírez Fernández MP, Gómez Moreno G, et al. Biomechanical and bone histomorphological evaluation of two surfaces on tapered and cylindrical root form implants: An experimental study in dogs. *Clin Implant Dent Relat Res.* 2013;15:799-808.
4. Lang NP, Pun L, Lau KY, Li KY, Wong MC. A systematic review on survival and success rates of implants placed immediately into fresh extraction sockets after at least 1 year. *Clin Oral Implants Res.* 2012;23:39-66.
5. Polizzi G, Grunder U, Goené R, Hatano N, Henry P, Jackson WJ, et al. Immediate and delayed implant placement into extraction sockets: a 5-year report. *Clin Implant Dent Relat Res.* 2000;2:93-9.

6. Siegele D, Soltesz U. Numerical investigations of the influence of implant shape on stress distribution in the jaw bone. *Int J Oral Maxillofac Implants.* 1989;4:333-40.
7. Esposito M, Hirsch JM, Lekholm U, Thomsen P. Biological factors contributing to failures of osseointegrated oral implants. (i). Success criteria and epidemiology. *Eur J Oral Sci.* 1998;106:527-51.
8. Chen ST, Wilson TG Jr, Hämmerle CH. Immediate or early placement of implants following tooth extraction: review of biologic basis, clinical procedures, and outcomes. *Int J Oral Maxillofac Implants.* 2004;19:12-25.
9. Fugazzotto PA. Success and failure rates of osseointegrated implants in function in regenerated bone for 72 to 133 months. *Int J Oral Maxillofac Implants.* 2005;20:77-83.
10. Hammerle CH, Chen ST, Wilson TG Jr. Consensus statements and recommended clinical procedures regarding the placement of implants in extraction sockets. *Int J Oral Maxillofac Implants.* 2004;19: 26-8.
11. Polizzi G, Grunder U, Goene R. Immediate and delayed implant placement into extraction sockets: A 5-year report. *Clin Implant Dent Relat Res.* 2000; 22:93-9.
12. Wilson TG, Weber HP. Classification of and therapy for areas of deficient bony housing prior to dental implant placement. *Int J Periodontics Restorative Dent.* 1993;13:451-9.
13. Becker W, Becker BE, Handelsman M, Ochsenein C, Albrektsson T. Guided tissue regeneration for implants placed into extraction sockets: A study in dogs. *J Periodontol.* 1991;62:703-9.
14. Wilson TG. Guided tissue regeneration around dental implants in immediate and recent extraction sites: Initial observations. *Int J Periodontics Restorative Dent.* 1992; 12:185-93.
15. Gher ME, Quintero G, Assad D, Monaco E, Richardson AC. Bone grafting and guided bone regeneration for immediate dental implants in humans. *J Periodontol.* 1994;65: 881-991.
16. Lim SA, Cha JY, Hwang CJ. Insertion torque of orthodontic miniscrews according to changes in shape, diameter and length. *Angle Orthod.* 2008;78:234-40.
17. Atsumi M, Park SH, Wang HL. Methods used to assess implant stability: current status. *Int J Oral Maxillofac Implants.* 2007;22:743-54.
18. Trisi P, De Benedittis S, Perfetti G, Berardi D. Primary stability, insertion torque and bone density of cylindrical implant ad modum Brånemark: Is there a relationship? An invitro study. *Clin Oral Implants Res.* 2011;22:567-70.
19. Makary C, Rebaudi A, Mokbel N, Naaman N. Peak insertion torque correlated to histologically and clinically evaluated bone density. *Implant Dent.* 2011;20:182-91.
20. McClanahan SF, Bartizek RD, Biesbrock AR. Identification and consequences of distinct Löe-Silness gingival index examiner styles for the clinical assessment of gingivitis. *J Periodontol.* 2001;72:383-92.
21. Khan S, Cabanilla LL. Periodontal probing depth measurement: a review. *Compend Contin Educ Dent.* 2009;30:12-4.
22. Steflik DE, Koth DL, Robinson FG, McKinney RV, Davis BC, Morris CF, et al. Prospective investigation of the single-crystal sapphire endosteal dental implant in humans: ten-year results. *J Oral Implantol.* 1995;21:8-18.
23. Brouwers JEIG, Lobbezoo F, Visscher CM, Wismeijer D, Naeije M. Reliability and validity of the instrumental assessment of implant stability in dry human mandibles. *J Oral Rehabil.* 2009; 36: 279-83.
24. Chong L, Khocht A, Suzuki JB, Gaughan J. Effect of implant design on initial stability of tapered implants. *J Oral Implantol.* 2009;35:130-5.
25. Tabassum A, Meijer GJ, Wolke JGC, Jansen JA. Influence of surgical technique and surface roughness on the primary stability of an implant in artificial bone with different cortical thickness: a laboratory study. *Clin Oral Implants Res.* 2010;21:213-20.
26. Turkyilmaz I, Mcglumphy EA. Influence of bone density on implant stability parameters and implant success: a retrospective clinical study. *BMC Oral Health.* 2008; 8: 32.
27. Friberg B, Sennersby L, Meredith N, Lekholm U. A comparison between cutting torque and resonance frequency measurements of maxillary implants: A 20-month clinical study. *Int J Oral Maxillofac Surg*1999; 28:297-303.
28. Kahraman S, Bal BT, Asar NV, Turkyilmaz I, Tözüm TF. Clinical study on the insertion torque and wireless resonance frequency analysis in the assessment of torque capacity and stability of self-tapping dental implants. *J Oral Rehabil.* 2009;36:755-61.
29. Degidi M, Daprile G, Piattelli A. Determination of primary stability: a comparison of the surgeon's perception and objective measurements. *Int J Oral Maxillofac Implants.* 2010;25:558-61.
30. Brouwers JE, Lobbezoo F, Visscher CM, Wismeijer D, Naeije M. Reliability and validity of the instrumental assessment of implant stability in dry human mandibles. *J Oral Rehabil.* 2009;36:279-83.
31. Al-Nawas B, Wagner W, Grötz KA. Insertion torque and resonance frequency analysis of dental implant systems in an animal model with loaded implants. *Int J Oral Maxillofac Implants.* 2006;21:726-32.
32. Javed F, Romanos GE. The role of primary stability for successful immediate loading of dental implants. A literature review. *J Dent.* 2010;38:612-20.

33. Degidi M, Piattelli A. 7-Year follow-up of 93 immediately loaded titanium dental implants. *J Oral Implantol.* 2005;310:25-31.
34. Rokn A, Ghahroudi AR, Mesgarzadeh A, Miremadi A, Yaghoobi S. Evaluation of stability changes in tapered and parallel wall implants: A human clinical trial. *J Dent (Tehran).* 2011;8:186-200.
35. Bilhan H, Geckili O, Mumcu E, Bozdog E, Sünbuloğlu E, Kutay O. Influence of surgical technique, implant shape and diameter on the primary stability in cancellous bone. *J Oral Rehabil.* 2010;37:900-7.
36. Menicucci G, Pachie E, Lorenzetti M, Migliaretti G, Carossa S. Comparison of primary stability of straight-walled and tapered implants using an insertion torque device. *Int J Prosthodont.* 2012;25Craniomaxillofac Surg. 2012; 40: 321-8.

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