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The evaluation of the effects of length and diameter of cast posts on their retention

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Abstract:
Objectives: *To evaluate the effects of length and diameter of cast posts and core on their retention.*
Materials and Methods: *Ninety six newly extracted anterior teeth were collected. The teeth were randomly divided into eight groups. Group 1 received a post of 8mm length and 1.4mm diameter. Group 2 received a post of 10mm length and 1.4mm diameter. Group 3 received a post of 12mm length and 1.4mm diameter. Group 4 received a post of 14mm length and 1.4mm diameter. Group 5 received a post of 8mm length and 1.6mm diameter. Group 6 received a post of 10mm length and 1.6mm diameter. Group 7 received a post of 12mm length and 1.6mm diameter. Group 8 received a post of 14mm length and 1.6mm diameter. Teeth were positioned in a universal testing machine with the posts engaged in a custom made special device. A constantly increasing tensile force was applied at a crosshead speed of 5mm/min to the posts until the cement failed. The samples were examined and the forces needed to remove the posts were recorded and subjected to statistical analysis.*
Results: *A significant variation in retention capacities was found among different lengths of posts (p<.05). The retention of posts with different diameters did not vary significantly (p<.05).*
Conclusions: *When the post length was 12 mm or less; the longer the post the higher the post retention. Larger post diameters were not associated with more retention. The longest post length and narrowest possible post diameter should be chosen, but it should be sufficient to resist bending and should not compromise apical seal.*
Keywords: *Cast post, post diameter, post length, retention*

I. Introduction

Endodontically treated teeth may not have sufficient coronal tooth structure to retain extracoronal restorations [1]. Various techniques have been introduced to address this problem. These techniques are based on the utilization of posts within the roots to provide adequate retention for the core that in turn provides the necessary retention required for the extracoronal restoration [2]. The procedure should not further weaken the tooth or risk the endodontic seal [2]. Recommendations of adequate length of gutta percha have ranged from 3mm [3,4] to 5mm [5], but the recommendation to leave 4mm [6] would appear to be the most popular.

Posts are either cast or prefabricated. Cast posts are completely determined by the dentist in terms of length, diameter and design. The impression can be made in either direct or indirect technique.

The importance of adequate post length to help maximize post retention is well-recognized [2]. However, the ideal length for the purpose of post retention is controversial [7]. There has been a trend towards maximizing post length in all but the longest teeth [3,6,8,9]. It has been recorded that an increase of 24% to 30% [10] in retention for post of 11mm compared with 7mm or 9mm, while others [11] discovered that increasing the length from 5 mm to 8 mm added only 1.23 times the retention. This has stimulated research into the length of gutta percha apical seal. Long posts have traditionally been considered to give better tooth support since they usually terminate well below the level of alveolar bone, which has usually been considered to be the critical area for tooth fracture [2]. However, it has been suggested that the use of posts to transfer stress away from the cervical portion of the tooth may create an area of stress concentration of the apical portion of the post [12,13]. It has been found that increasing the length of a post from approximately half to three-quarters of the root length did not appear to significantly decrease stress at the level of the alveolar bone in vitro [2]. It may be desirable to limit post depth to just over half of the length of the root where adequate core retention is not compromised. The in vitro experiments revealed that the increased post diameter leads to increased retention because of the increase in the surface area available for adhesion [6,14-16]. On the other hand, other studies reported that increasing post diameter was an inefficient way of increasing its retention [7,17] and reduce the fracture strength of teeth [13,18]. Some researchers suggested that the optimum diameter of the post is one-third the diameter of

the root [19,20]. In order to reduce failures and fractures, Mou et al [21] recommended that the optimum cast post to root diameter ratio should be approximately 1:4.
However, contradictory evidence in the literature still exists regarding the effect of length and diameter of the posts on their retention.

The aim of the current study was to determine the effect of different lengths and diameters of cast posts and cores on their retention potential.

II. Materials And Methods

Ninety six intact maxillary teeth were selected for the present study. They included 63 maxillary central incisors, 20 canines, and 13 single-rooted premolars of similar size. These teeth were caries-free and without restorations or cracks. The teeth were stored in a solution of distilled water and 5% thymol at room temperature after extraction until cementation of the posts [22].

Samples preparation

Clinical crowns of the teeth were removed with a diamond bur (Many Inc, Japan). The section was made perpendicular to the long axis of the tooth under constant water coolant. Any remaining pulpal tissue was removed with a barbed broach (Nerve broach, Munchen, Germany). The root length was determined by insertion of a No. 15 file (Many Inc, Japan) into the canal until it appeared at the apex. The working length was recorded at 0.5 mm shorter than that length. Instrumentation of the canal continued from No. 15 file to a No. 25 file. A No. 2 gates glidden drill (Union Broach Co., Long Island City, NY) was used to a depth of 2 to 3 mm beyond the point where resistance was first encountered. Filing the canal to a size 40 file completed the preparation of the canal. The canals were irrigated with 2% sodium hypochlorite solution after use of each file and each gates glidden drill.

The canal space was thoroughly dried with 10 medium paper points (MetaDent. Korea). Sealapex (Kerr Italia, Spa) was mixed according to the manufacturer's instructions. A size 20 file was used to carry the sealer into the canal space. A size 40 primary gutta percha cone (Ace One-Endo Aceone Dent Ind., Korea) was coated with the sealer and inserted into the canal; obturation was completed with accessory gutta percha cones with vertical and lateral condensation techniques. Excess gutta-percha was removed with a hot amalgam condenser. The teeth were then stored in distilled water for 24 hours before the post space was prepared.

The teeth were randomly divided into eight groups. Group 1 received a post of 8mm length and 1.4mm diameter. Group 2 received a post of 10mm length and 1.4mm diameter. Group 3 received a post of 12mm length and 1.4mm diameter. Group 4 received a post of 14mm length and 1.4mm diameter. Group 5 received a post of 8mm length and 1.6mm diameter. Group 6 received a post of 10mm length and 1.6mm diameter. Group 7 received a post of 12mm length and 1.6mm diameter. Group 8 received a post of 14mm length and 1.6mm diameter.

Preparation of the post space and impression making

A composite ball was made at the apex of each tooth and then the teeth were mounted in acrylic resin blocks (BMS, Italy), and positioned in a milling machine (BEGO Bremer Golds chlagerei Wilh. Herbst Gmbh & Co., Bremen, Germany) to create the post space with peeso reamers (Dentsuply maillefer Instrument SA 1338 Ballaigues, Switzerland) (Figure 1). Each reamer was used for 10 teeth and then discarded. The canals were lubricated with petroleum jelly and the impressions for the posts were made using the direct technique. Dura lay® acrylic resin (Richard L. Milano, Torino, Italy) was mixed according to the manufacture's instructions and carried to the canal using the lentulospiral (Henry J. Schein, Washington, NY). After setting of the acrylic resin the cores were then built up.

Casting the impressions

Dura lay® impressions were sprued and invested with an investment (BEGO Bremer Goldschlagerei Wilh. Herbst Gmbh &Co., Bremen, Germany). Cobalt–Chrome base alloy (BEGO Bremer Goldschlagerei Wilh. Herbst Gmbh &Co., Bremen, Germany) was used for casting (Figure 2), and then the posts were fitted into their corresponding canals by minor adjustments.

Cementation of the posts

Escape channels were made in the posts to allow escape of excess cement then the posts were blasted with 60µm aluminum oxide [23] (BEGO Bremer Goldschlagerei Wilh. Herbst Gmbh & Co., Bremen, Germany). Posts spaces were rinsed with 5.2% sodium hypochlorite followed by tap water. Glass ionomer cement (Medicem, Germany) was mixed according to the manufacturer's instructions then a lentulospiral (Henry J. Schein, Washington, NY) was used to carry the glass ionomer cement into the canal space. The lentulospiral is considered to give better spinning and spreading of the cement because of centrifugal dispersing of the cement. This method also reduces voids and increases the contact of the cement with the canal walls and the posts. The posts were fitted in under a constant a pressure of five kilograms for three minutes and then allowed to set for ten minutes, all teeth were then stored in 100% humidity.

Performing the experiment

The samples were positioned in a universal testing machine (Instron, UK) with the posts engaged in custom made special device constructed to ensure vertical application of tensile forces during the test (Figure 3). A constantly increasing tensile force was applied at a crosshead speed of 5mm/min to the posts until the cement failed. The samples were examined and the forces needed to remove the posts were recorded.

Statistical Analysis:

The data were analyzed using the Statistical Package for the Social Sciences 16 (SPSS 16, SPSS Inc., Chicago, IL, USA). Frequency tables were generated and means and standard deviations were calculated for all groups. The ANOVA test was used to compare different groups. ANOVA test was used to compare groups when different post lengths or diameters were used (Tables 3-5), while paired samples t-test was used to identify the difference in retentive forces recorded for different groups (Table 2). For all statistical analysis, the significance level was set at $P \leq 0.05$.

III. Results

Tensile forces required to dislodge the cemented posts from their corresponding teeth were recorded. Table 1 presents the mean, standard deviation, maximum and minimum retentive forces of posts with different lengths and diameters.

When the mean retentive force was correlated with the groups; the mean retentive force was found to be significantly different between groups (p=0.000) (Table 2). Group 1 (post length=8mm and post diameter=1.4mm) had significantly less retentive forces than group 8 (post length=14mm and post width=1.6mm) (Tables 1 and 2). The posts with shorter and narrower posts had less retentive forces than posts that had longer and wider posts.

Moreover, ANOVA test revealed significant differences in mean retention forces between posts of different lengths when post diameter was 1.6mm (Table 3). Group 2 showed significantly higher retention forces than group 1 (p =.019) and group 3 shows also significantly higher retention than group 2 (p =.010). However, there was no significant difference between group 4 and group 3 (p =.366). The retention was affected by post lengths up to 12mm; however, beyond that there was no statistical significance of the post length.

Similarly, a significant difference in mean retention existed between posts of different lengths when post diameter was 1.4mm (Table 4). Group 6 showed significantly higher retention than group 5 (p =.024) and group 7 showed also significantly higher retention than group 6 (p =.0001). However, there was no significant difference between group 8 and group 7 (p = 1.00). The retention was affected by post lengths up to 12mm; however, beyond that there was no statistical significance of the post length.

Nevertheless, when all samples were grouped into two groups according to the diameter; there was no significant difference between the posts' retentive forces for posts that have a diameter of 1.6mm and those that have a diameter of 1.4mm (p=.083) (Table 5). Various post lengths could affect the results and masked the effect of increasing the diameter because of the changes in the post's surface area. A 2mm increase in the length of 1.4 and 1.6mm diameter posts led to an increase in the post surface area by 8.8mm^2 and 10.01mm^2 respectively. However, increasing the diameter of an 8 mm long post from 1.4 to 1.6mm was associated with an increase in the surface area by 5.5mm^2.

IV. Discussion

This in vitro study was performed to evaluate the effect of cast posts length and diameter on their retention. All efforts were made to minimize the variability between the samples. All teeth were stored in the same media (distilled water and 5% antifungal thymol agent) because they had to be stored for extended period as collection proceeded [22]. The posts were blasted using 60µm aluminum oxide since this technique has been shown to lead to a significant increase in the retention of castings by increasing surface roughening and also by removing debris and contaminants [23]. Posts spaces were thoroughly rinsed with 5.2% sodium hypochlorite followed by tap water and dried with paper points [12]. This procedure will help the post space wall to be free of root canal sealant, debris, petroleum jelly and dentinal smear layer [24]. Morgano and Milot [25] reported that that even a small nodule on the post surface or temporary cement residue in the canal can generate enough force to cause root fracture during and after post cementation.

The posts were fitted in under a constant pressure of five kilograms for three minute and then allowed to set for ten minute. In previous studies [26,27], finger pressure was used for cementation. However, finger pressure is not standard since fatigue might occur. All teeth were then stored in 100% humidity so that the samples would not get dry until performing the experiment.

The results showed that the length of the post had statistically significant relationship to the post retention. Retention tended to improve with increasing the length of the post. This can be explained by the increase in the surface area of a longer post. However, the lack of further retention improvement between the 12 and 14mm post length could be due to that teeth usually taper near the apex and thus the surface area decreases. It should be remembered that a 14 mm post is very rare to fabricate since the length of the roots that can be used to receive a post is limited by the apical seal, the curvature of the roots and the small diameter of the apical part of the root.

The results concur the previous reports that considered post length as a key factor in increasing retention [2,3,6,8,9]. An increase in length from 8mm to 12mm added 1.2 times the retention, which was also confirmed by Ruemping et al [11]. Also, Johnson [10] recorded an increase of 24% to 30% in retention for post of 11mm compared with 7mm or 9mm post. Long posts have traditionally been considered to give better tooth support since they usually terminate well below the level of alveolar bone, which has usually been considered to be the critical area for tooth fracture [2]. However, it has been suggested that the use of posts to transfer stress away from the cervical portion of the tooth may create an area of stress concentration of the apical portion of the post [12,13,18]. In contrast, others have found that although apical stresses increase with post placement, they are less than 20% of the stresses at the high bending stress regions (the level of the alveolar bone), and that although teeth with posts fracture more apically they have double the resistance to fracture controls [28].

It was found that post diameter had no significant relation to post retention; this can be explained by the minimal increase in surface area when increasing the diameter in comparison to the length. This finding is in agreement with Henry [9] and Reinhardt [29] who showed their inability to demonstrate any relationship between post diameter and retention. Also, it agrees with those who claimed that no such relation is existing [7,17,30]. On the other hand, it disagrees with those who believed that increased post diameter leads to increased retention because of the increase in the surface area available for adhesion [15,16]. Their findings were significant only if the diameter of the post was increased to a large extent. This could undermine the fracture resistance of the tooth [13,18]. Some authors advocate that the preservation of residual dentin is of utmost importance [31]. AL-Omiri et al [13] conducted a finite element stress analysis of endodontic posts and concluded that an increase in post diameter elevated stresses in the radicular dentine. Therefore, they suggested restricting the diameter of the post to conserve the remaining tooth structure (conservationist approach) [5]. Stern and Hirshfeld [19] suggested that the optimum diameter of the post is one-third the diameter of the root. Tilk [32] recommended ranges of dowel diameter for each tooth. He suggested that a post with one-third the diameter of the root preserves sufficient tooth structure (proportionist approach). Halle [33] proposed that preservation of a 1.75 mm of sound dentin around the entire circumference of the post is sufficient to resist fracture of the tooth (preservationist approach). For selecting the post diameter, it is suggested that the proportionist and preservationist approach applied.

Further studies on different post materials and using different types of cements are recommended. Also, it is recommended to study the effects of cyclic loading and thermal cycling on retention forces before application of tensile stresses to dislodge the posts.

V. Conclusions

Finally, it can be concluded that when the post length is less than 12 mm; increasing the post length would increase its retention significantly; it should be as long as possible but, must not jeopardize the apical seal or cause perforation of the root. Also, increasing the post diameter to gain more retention is insufficient way to improve retention and will pose a threat of potential weakening of the tooth structure. Therefore, the narrowest possible post diameter should be chosen, but it should be sufficient to resist bending and distortion.

References

[1]. Hoffmann-Axthelm W. A history of dentistry. Quintessence 1981; 271.

[2]. Hunter AJ, Feiglin B, Williams JF. Effect of post placement on endodontically treated teeth. J Prosthet Dent 1989; 62:166-172.

[3]. Skol DJ. Effective use of core and post concept. J Prosthet Dent 1984; 52:231-234.

[4]. Allison DA, Michelich RJ, Walton RE. The influence of master cone adaptation on the quality of the apical seal. J Endod 1981; 7:61-65.

[5]. Mattison GD. Photoelastic stress analysis of cast gold endodontic posts. J Prosthet Dent 1982; 48:400-407.

[6]. Sorensen JA. Intacoronal reinforcement and coronal coverage: a study of endodontiocally treated teeth. J Prosthet Dent 1984; 51:780-784.

[7]. Ahmad M, Jones JC. Retention of post crowns: a summarizing review. J Dent Malaysia 1984; 7:3-9.

[8]. Gutman JL. Preparation of endodontically treated teeth to receive a post- core restoration. J Prosthet Dent 1977; 38: 413.

[9]. Henry P J, Bouer RC. Post core systems in crown and bridgework. J Aust Dent 1977; 22:128-131.

[10]. Johnson JK, Schwartz NL, Blackwell RT. Evaluation and restoration of endodontically treated posterior teeth. J Am Dent Assoc 1976; 93:631-634.

[11]. Ruemping DR, Lund MR. Retention of dowels subjected to tensile and torsional forces. J Prosthet Dent 1979; 45:164-174.

[12]. Aquaviva F, Sebastian villa, Avedem LM. Factors affecting the fracture Resistance of post-core reconstructed teeth. Int J Prosthodont 2001; 14:355-363.

[13]. AL-Omiri MK, Rayyan M, Abu-Hammad O. Stress analysis of endodontically treated teeth restored with post-retained crown: an FEA study. J Am Dent Assoc 2010; 142(3):289-300.

[14]. Mattison GD, Delivanis PD, Thacker RW, Hassell KJ. Effect of post preparation on the apical seal. J Prosthet Dent 1984; 51:785-789.

[15]. Colman HL. Restoration of endodonticaly treated teeth. J Dent Clin North Am 1979; 23:647-662.

[16]. Greenfield RS. Factors affecting dowel selection and use in endodontically treated teeth. J Can Dent Assoc 1983; 49:777-83.

[17]. Standlee JP, Caputo AA. Endodontic dowel retention with resinous cement. J Prosthet Dent 1992; 68,913-917.

[18]. AL-Omiri MK, Mahmoud A, Rayyan M, Abu-Hammad O. Fracture resistance of teeth restored with post retained restorations: An overview. J Endod 2010;36(9):1439-1449.

[19]. Stren N, Hirshfeld Z. Principles of preparing endodontiocally treated teeth for dowel and core restoration. J Prosthet Dent 1973; 30: 162-165.

[20]. Sirimai S, Riis DN, Morgano SM. An in vitro study of the fracture resistance and the incidence of vertical root fracture of pulpless teeth restored with six post-and-core systems. J Prosthet Dent 1999;81:262-9.

[21]. Mou YB, Chen YM, Smales RJ, Yip KH. Optimum post and tooth root diameters for a cast post-core system. Am J Dent 2009;22(5):311-4.

[22]. AL-Omiri MK, AL-Wahadni AM. An ex vivo study of the effects of retained coronal dentine on the strength of teeth restored with composite core and different post and core systems. Int End J 2006; 39:890-899.

[23]. Button GL, Barnes RF, Moon PC. Surface preparation and the shear bond strength of the casting cement interface. J Prosthet Dent 1985; 53:34-38.

[24]. Yaman P, Zillich R. Restoring the endodontically treated bi-rooted premolar-the effect of endodontic and post preparation on width of root dentin. J Mich Dent Assoc 1986; 68:79-81.

[25]. Morgano SM, Milot P. Clinical success of metal posts and core. J Posthet Dent 1993; 70:11-16.

[26]. Sorensen JA, Engelman MT. Effect of post placement on fracture resistance of endodontiocally treated teeth. J Prosthet Dent 1990; 64: 419-424.

[27]. Shillingburg HT, Kessler JC. Restoration of endodontically treated teeth. Chicago Quintessence; 1982, p.13.

[28]. Kantor ME. A comparative study of restorative techniques for pulp less teeth. J Prosthet Dent 1977; 38:40-45.

[29]. Reinhardt RA, Krejici RF, Paoye Stennerd JG. Dentine stresses in post-reconstructed teeth with diminishing bore support. J Dent Res 1983; 62:1002-1008.

[30]. Deutsch AS. Root fracture during insertion of prefabricated posts related to root size. J Prosthet Dent 1985; 53:786-789.

[31]. Pilo R, Tamse A. Residual dentin thickness in mandibular molars prepared with gated gladden and para post drills. J Prosthet Dent 2000; 83:617-623.

[32]. Tilk MA. A study of mandibular root width to determine dowel size. J Endod 1979; 31:264-526.

[33]. Halle E. An in vitro comparison of post and core and a custom hollow post and core. J Endod 1990; 10:96-100.

FIGURE LEGENDS

Figure 1: Sample mounted on the milling machine to create the post space.

Figure 2: The final fabricated Cobalt-Chrome cast post.

Figure 3: Custom made special device constructed to ensure vertical application of tensile force.

Figures

Figure 1: Sample mounted on the milling machine to create the post space.

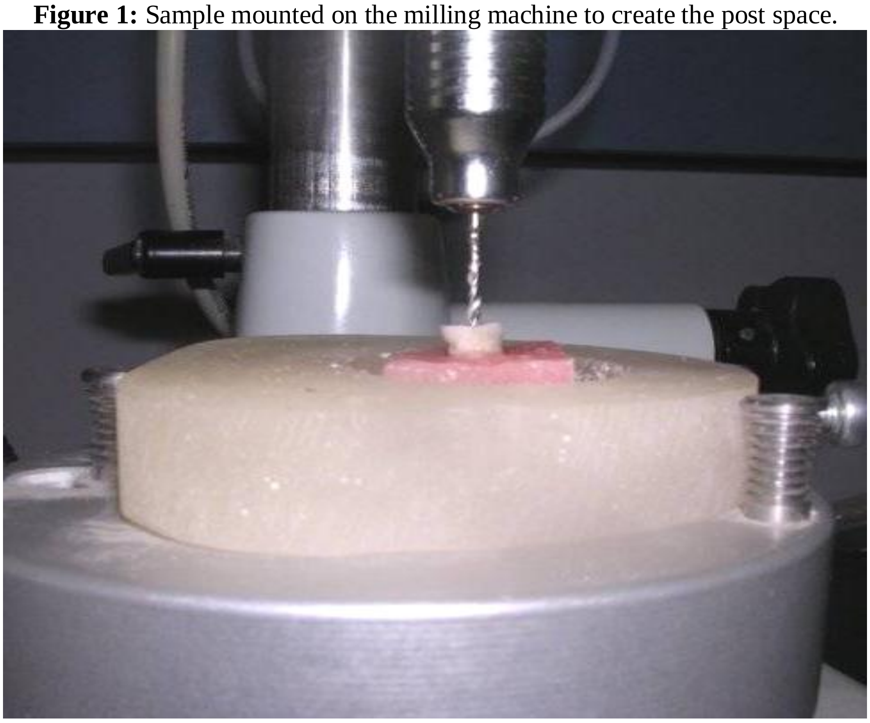
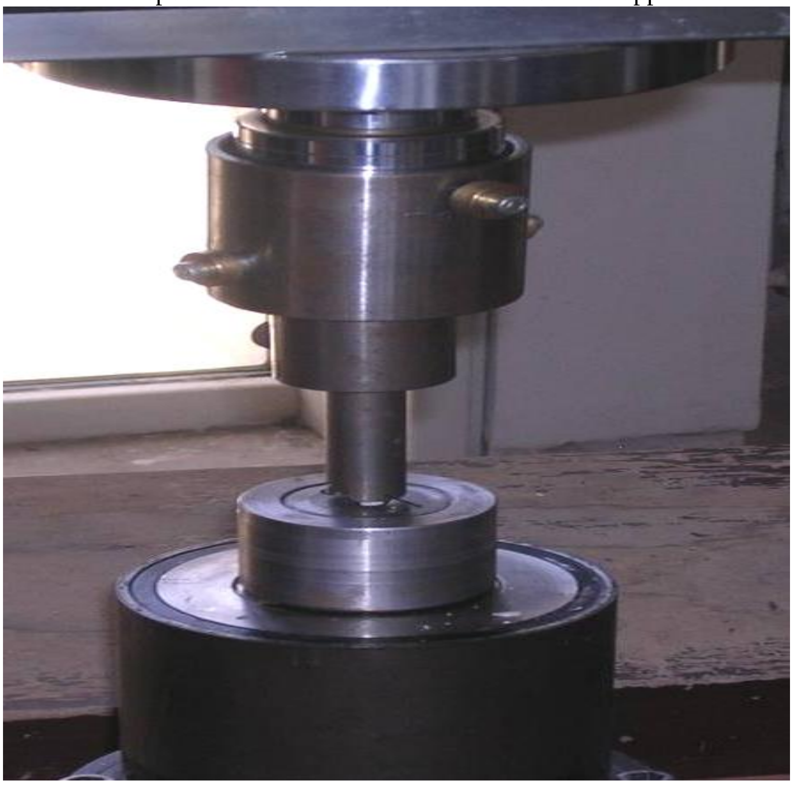


Figure 2: The final fabricated Cobalt-Chrome cast post.

Figure 3: Custom made special device constructed to ensure vertical application of tensile force.



Tables

Table 1: Mean, standard deviation, maximum and minimum retentive forces of posts with different lengths and diameters.

Post length (mm)	Mean Retentive Force (Newton)		Standard Deviation		Minimum Retentive Force (Newton)		Maximum Retentive Force (Newton)	
	A	B	A	B	A	B	A	B
8	206.63	215.0	10.78	10.6	187	200	222	233
10	227.63	236.0	6.61	11.2	219	219	240	260
12	250.25	258.5	15.28	32.3	233	190	278	320
14	253.50	271.4	18.01	24.0	230	235	280	325
Total	234.50	245.2	23.06	30.2	187	190	280	325

A= Posts with 1.4 mm diameter, B= Posts with 1.6 mm

Table 2: Paired samples t-test of the relationship between retentive force and study groups.

Paired Samples Test*							
	Paired Differences						
			95% Confidence Interval of the Difference				
Pair	Mean	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Group – Retentive force	-235.364	2.782	-240.887	-229.841	-84.61	95	.000

*Paired samples correlation: correlation coefficient=0.509 and p=0.000.
Sig= Significance, df= Degree of Freedom.

Table 3: ANOVA test for retentive forces of post with 1.6 mm diameter and different post lengths.

GROUP I	GROUP J	Mean Difference (I-J)	Significance (p=)
8 mm length	10 mm length	-21.0	.019
	12 mm length	-43.5	.000
	14 mm length	-56.4	.000
10 mm length	8 mm length	21.0	.019
	12 mm length	-22.5	.010
	14 mm length	-35.4	.000
12 mm length	8 mm length	43.5	.000
	10 mm length	22.5	.010
	14 mm length	-12.9	.366
14 mm length	8 mm length	56.4	.000
	10 mm length	35.4	.000
	12 mm length	12.9	.366

Table 4: ANOVA test for retentive forces of post with 1.4 mm diameter and different post lengths.

GROUP I	GROUP J	Mean Difference (I-J)	Significance (p=)
8 mm length	10 mm length	-21.00	.024
	12 mm length	-43.63	.000
	14 mm length	-46.88	.000
10 mm length	8 mm length	21.00	.024
	12 mm length	-22.63	.013
	14 mm length	-25.88	.004
12 mm length	8 mm length	43.63	.000
	10 mm length	22.63	.013
	14 mm length	-3.25	1.000
14 mm length	8 mm length	46.88	.000
	10 mm length	25.88	.004
	12 mm length	3.25	1.000

Table 5: Means and standard deviations for retention force of the posts with diameter 1.6 mm and 1.4 mm regardless their length.

Diameter	N	Mean Retentive Force (Newton)	Standard Deviation	Standard Error Mean	P value*
1.6 mm	48	245.2	30.2	4.4	.083
1.4 mm	48	234.5	23.1	4.1	

* Using ANOVA test