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THE COMPARISON OF INITIAL RETENTIVE FORCE IN DIFFERENT DOUBLE CROWN SYSTEMS

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Statement of problem. Various double crown systems have been used with removable partial dentures in the clinical field. Although retentive force between inner and outer crown are affected by several factors, differences between the retentive forces of different double crown system types are expected.

Purpose. The purpose of this study was to evaluate the initial retentive force of outer crowns fabricated by the conventional casting technique in conus and hybrid double crowns.

Material and methods. Ten double crowns were fabricated. The groups were as follows. Group 1, double crowns of hybrid inner and outer crowns using the conventional casting method; Group 2, double crowns of conus inner and outer crowns using the conventional casting method. Tensile strengths of double crowns when the inner and outer crowns were separated on a universal testing machine were measured. These values of retentive force were then statistically analyzed using the Kruskal-Wallis test.

Results. Retentive force in group 2 was significantly higher than that in group 1 ($p<.05$).

Conclusion. The initial retentive forces of double crowns were affected by the types of the double crown system.

Key Words

Double crowns, Retentive force, Telescopic crowns

The clinical use of removable partial denture is influenced by the concept of connecting remaining teeth and removable prostheses. An appropriate retainer for successful restoration is selected after considering the number and alignment of natural teeth, the periodontal condition of remaining teeth, and patient's esthetic demands and financial limitations. Conventional prosthodontic treatment using surveyed crowns and partial dentures with clasps have been widely used. However, these types of retention system are known to impose lateral forces on remaining abutments.[1,2]

Telescopic or double crowns have proved to be an effective means of retaining removable partial dentures.[3,4] The use of telescopic retainers for the stabilization and retention of removable dental restorations was first reported at the end of the 19th century,[5] and since their introduction, treatments using double crown techniques have shown good longevity.[6-9] The double crown system retains dentures more effectively than conventional clasp-retained removable partial dentures and also shows more favorable transmission of occlusal loading to the axis of abutment teeth.[10] When the double crown system is used as a retentive component, it limits the movement of removable partial dentures and integrates the denture base and the occlusal portion of the retentive component, and prevents the concentration of occlusal stress. It provides guidance, support, and protection to removable partial dentures from movements that might dislodge them.[3] And as double crown-retained removable partial dentures transfer forces along the long axis of abutment teeth, it produces less mobility of the abutment teeth than removable partial dentures with clasps.[9,11]

Compared to clasp-retained removable partial dentures, the double crown system may also provide advantages in terms of denture insertion and removal for older people with reduced dexterity.[6] In addition, prostheses and abutments can be cleaned easily, which is important for elderly or handicapped patients. Moreover, they can be modified when extraction of an abutment is necessary. The double crown system consists of an inner crown permanently cemented to an abutment tooth and an outer crown rigidly anchored in the detachable prosthesis.[12] The inner crown protects the abutment tooth from caries, chemical irritation, and thermal irritation, and the outer crown is an integral part of the removable partial denture, and serves as its anchorage for remaining dentition.[5]

The double crown systems are of various types, and depending on the form of retention, double-crown systems can be divided into three different types. Three different types of double crown systems are telescopic, conus, and hybrid crown. These three systems have same basic form in that they are composed of inner and outer crowns. However, they are different in terms of degree of axial wall and biomechanics.

Telescopic crowns achieve retention by using the friction of parallel-milled surfaces. This design involves intersurface friction from parallel walls during denture insertion and removal as the two parts engage and disengage themselves.[4] The fabrication of parallel-sided crown is considered to be technically difficult, because this system requires a clear fit between inner and outer crown for appropriate retention.[6] The major disadvantages of parallel telescopic crowns are overcontour resulted from the veneering technique, the problem of attaining approximately parallel preparations on vital abutment teeth, and the challenge for patients to remove the denture without canting.[4]

To solve the problems of parallel telescopic crowns, conical type retainers was introduced by Körber.[4] The tapered configuration of the contacting walls generates a compressing interface tension based on a wedging action.[14] This configuration provides good retention, less abrasion of the fitting surface, and easier patient handling compared with the parallel telescopic system. This crown called the conus crown, exhibits friction only when completely seated by using a wedging effect.[3] The retention force of each conical crown is recommended to be 5N to 10N.[4] In addition, the alloy-related adhesive coefficient and the thickness of the outer crown also contribute to prosthesis retention.[4]

Hybrid crowns have the advantages of telescopic and conus crowns. Hybrid crowns have a 3 mm parallel milled axial wall gingivally and inclined wall which follows the abutment contour occlusally. With hybrid crowns, reduction of natural teeth is reduced versus the other double crown and they produce better esthetic results than conus crown.

Some authors have estimated changes in the retentions of double crowns caused by repeated insertion and separation, because information regarding long-term use is lacking.[15,16] According to these studies, retention of double crowns is reduced with long-term use. However, Güngör et al.[16] reported in his study with double crowns in which cyclic insertion-removal sequences were done, that only until the initial cyclic procedures of 500 procedures were performed, changes in retentive force could be found and there were no further changes. So the initial measurement of initial retention is also of importance and initial retention usually determines the retention after long-term use.

The purpose of this in vitro study was to compare the initial retentive forces in the hybrid double crown system and conus double crown system using the conventional casting techniques.

MATERIALS AND METHODS

Fabrication of double crowns

For this study 10 dies for double crowns were fabricated. One upper premolar was prepared for a double crown retainer. Ten impression takings of prepared tooth were taken with silicone rubber impression material (Extrude, Romulus, MI) and silicone putty material (Extrude XP Romulus, MI). Dental stone (Hi-koseton, Maruishi Gypsum Co, Osaka) was poured into impressions. On each die, wax up for inner crown was done. Two kinds of inner crown were fabricated. Five inner crowns were fabricated for hybrid crowns and 5 others were made for conus crowns. Castings were made using Au-Ag-Pd alloy (Solaro 3, Metalo dental AG, Oensingen, Switzerland). Five inner crowns for hybrid crowns had a 3 mm parallel axial wall gingivally and a 3 mm inclined plane, which conformed to the outer contour of prepared teeth occlusally. Five inner crowns for conus crowns with heights of 6mm and a cone angle of 2 degrees were fabricated. The inner crown castings were polished using milling machine (Frasgerat F1, Degussa, Frankfurt). Inner crown castings were cemented to a testing rod made of pattern resin (Pattern resin, GC Corp, Tokyo, Japan) using zinc phosphate cement (Fleck' s, Mizzy Inc. Cherry Hill, NJ).

Outer crowns were prepared on inner crowns. Outer crowns were made for each of these 10 inner crowns. All outer crowns had a small loop on top for connection to the universal testing machine. The experimental groups are presented in Table I. Casting and grinding procedures for outer crowns were completed and they were fully adapted on inner crowns. Outer crowns were adjusted to have a clear fit; other treatments that might have affected outer crown retention were not performed. All of the prepared samples for measurement of retentive force were presented in fig. 1 and fig. 2. All inner and outer crown fabricating procedures were performed by one dental technician.

Measurement of the retentive force of double crowns

An inner crown was placed into the holding apparatus of a universal testing machine (Instron 3365, Instron Corp., Canton, Mass), and the outer crown was placed onto the inner crown and connected to the holding apparatus of a universal testing machine.

Compressive force was applied to the inner-outer crown assembly at a cross head speed of 100cm / min until full seating was achieved, and then tensile strength was measured at the same cross head speed(Fig. 3). For all measurements, artificial saliva (Taliba, Hanrim Pharm. Co., Seoul) was

Table I. Group classification according to type of double crowns

	Inner crown	Outer crown
Group 1	hybrid crown	casting technique
Group 2	conical crown	casting technique

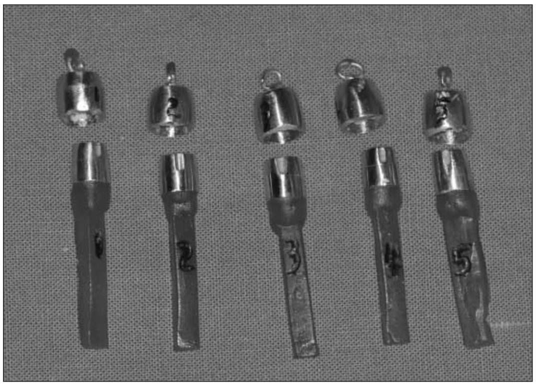

Fig. 1. Hybrid double crowns using casting technique in group 1.

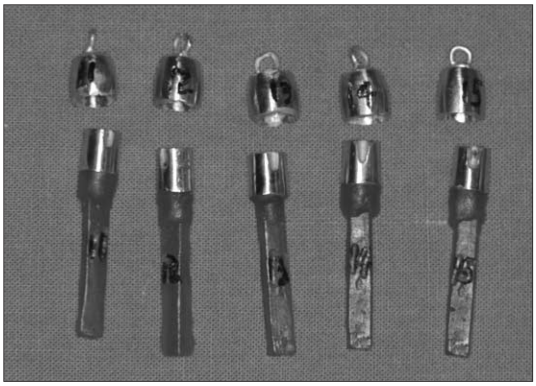

Fig. 2. Conical crowns using casting technique in group 3.

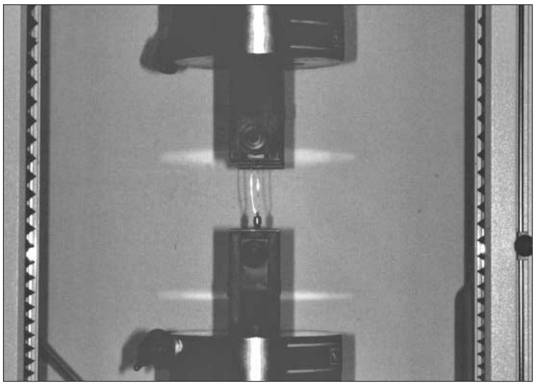

Fig. 3. Measurement of the tensile strength of a double crown.

applied between inner and outer crowns. Measured values were transferred to a personal computer. Retentive force values were statistically analyzed using the Kruskal-Wallis test using statistical software (SAS 9.1 SAS Institute Inc, Cary, NC).

RESULTS

Differences in retentive forces of inner and outer crown assemblies in the 2 groups are shown in Table II. The average retentive force in group 2, in which the hybrid outer crowns was used showed higher value than those of group 1 ($p=.0198$).

DISCUSSION

In this study, hybrid double crowns fabricated using the conventional casting method presented higher initial retentive forces than conus double crowns.

In this study conical crowns were used in group 2. These were conical crowns with 2 degree taper. Ohkawa et al reported that retention values decreased as conus angle increased,[15] and

Table II. Results of measurements of tensile strength

	Number of samples	Mean(N)	Standard deviation(N)
group 1	5	5.9	2.0
group 2	5	11.1	3.9

other authors agreed that retention decreases as conus angle increases and recommended that for long-term use the conus angle of telescopic crowns should not be tapered more than 2 degrees.[16,17]

When double crown retained removable partial denture are used in intraorally, the layer of saliva which wets both inner and outer crowns serves simultaneously as a lubricant and separating material, and thus reduces friction. Güngör et al reported that the reason for the great loss of retention of outer crowns is that removals are conducted in a dry medium.[16] In the present study, artificial saliva was applied during tensile force measurements. Changes in the surface characteristics of the friction surfaces of telescopic crowns might cause differences in retentive forces.

In the present study, before tensile forces were measured, seating force at a cross head speed of 100 cm / min was applied using the universal testing machine. Seating force is thought to affect resultant retentive force. Ohkawa et al prepared five telescope crowns for four groups with 0-, 2-, 4-, 6- degree cone angles and the same height (5 mm).[15] The retentive force for each specimen was measured after exerting seven seating forces of 1, 2, 3, 4, 5, 10, and 15 kg, and retentive force increased with increased seating force; no differences in retentive forces were observed for seating forces > 5KG. Moreover, Ohkawa et al reported no significant retentive force differences when seating forces were applied at seven crosshead speeds, i.e., 0.05, 2.5, 5, 10, 25, 50, and 100 cm / min.[15]

Several authors have reported that after repetitive insertion and separation cycles for double crowns, retention were reduced.[10,15,16] Clinically, some removable partial dentures with double crowns showed diminished retentive force after prolonged use. Thus, some authors suggested the use of auxiliary retention devices.[10,18] In the present study, repetition of insertion and separation cycles on inner and outer crowns were not performed. This represents a study limitation and further studies are needed. When the double crown system is used to retain removable partial dentures, precise frictional retention between inner and outer crowns is required. The friction force is the main source of retentive force in the double crown system. Special laboratory technical skills and knowledge on behalf of dental technicians are required to fabricate double crown systems successfully.

CONCLUSION

In this study initial retentive forces of hybrid double crown systems and conus double crown systems using conventional casting technique were compared. The tensile strength between inner and outer crown in the hybrid double crown system were higher than that of conus double crown. The initial retentive forces of double crowns were found to be affected by the shape of the double crown system.

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