CONNECTING RIGIDITIES OF VARIOUS PRECISION ATTACHMENTS COMPARED WITH THE CONICAL CROWN RETAINED TELESCOPE

Chau-Hsiang Wang, Huey-Er Lee, Je-Kang Du, and Yoshimasa Igarashi[1]
Department of Dentistry, Kaohsiung Medical University Hospital, Kaohsiung, Taiwan;
[1]Department of Removable Prosthodontics, Matsumoto Dental University, Nagano, Japan.

The purpose of this investigation was to observe the connecting rigidity of various precision attachments and to compare their connecting rigidities with the conical crown retained telescope (CCT). The connecting rigidity of a retainer was assessed using the flexibility test to measure the mesial and distal end displacements. Four precision attachments were analyzed: the dovetail slide attachment beyeler, cylindrical slide attachment, Spang Stabilex and Mini SG. The CCT was used as the control. Although there were many statistically significant differences between the displacements with the various attachments, displacements when vertically loaded were very small: all mesial end displacements were within 3 μm and distal end displacements were 21.4 μm. The largest of the mesial end displacements when horizontally loaded was as large as 44.5 μm (dovetail slide beyeler), while the others were all below 16.5 μm. The same phenomena occurred with the distal end displacements when horizontally loaded: the largest was seen with the dovetail slide beyeler, followed sequentially by the Spang Stabilex, CCT, cylindrical slide, and the Mini SG. The distal displacement with the dovetail slide beyeler was as large as 75.2 μm; those with the others were all below 31.2 μm, with numerous statistically significant differences between the displacements with the various attachments. Thus, connecting rigidities of rigid precision attachments are very similar to CCT, and only the dovetail slide beyeler attachment is too weak to resist horizontal displacement force.

Key Words: connecting rigidity, precision attachment, conical crown telescope, distal extension removable partial denture
(*Kaohsiung J Med Sci* 2005;21:22–8)

The connecting rigidity [1] of a retainer is related to the stress distribution between abutments and the denture foundation for a distal extension removable partial denture (RPD) [2–6]. That is, if one uses the more rigid connection of a retainer, one can obtain the least denture mobility and vice versa [7]. The conical crown retained telescope (CCT) system is one such rigid retainer that was developed by Körber in the 1960s [8]. Over the past three decades, long-term follow-up studies [9,10] as well as abundant clinical experience [11] have proven its rigidity and success in prognosis. Some clinicians will select CCT to design a distal extension RPD because of its rigid connection, but CCT is contraindicated in some patients because of the esthetic problems of an exposed cervical metal collar and metal-colored inner crowns when the removable denture is taken out, especially when the abutments are the anterior teeth. In this situation, some other form of attachment would normally be advised.

Over the years, many well-developed precision attachments have been produced [12,13], but until now, we have

Received: February 19, 2004 Accepted: December 15, 2004
Address correspondence and reprint requests to: Dr. Je-Kang Du, Department of Dentistry, Kaohsiung Medical University Hospital, 100 Shih-Chuan 1st Road, Kaohsiung 807, Taiwan.
E-mail: dujekang@ms31.hinet.net

not been aware of their properties of connection, and there are no data to compare them with the effectiveness of the CCT system. Therefore, this study determined the connecting rigidity of various precision attachments and compared them with the CCT system.

Materials and Methods

The connecting rigidity of a retainer was assessed using the flexibility test [14]. The first step was to prepare an abutment. The preformed model (model no. A225, Nissin, Tokyo, Japan) was a suitably prepared mandibular first premolar abutment model for a full cast crown. A duplicate impression was then made with silicone duplicating material (Duplicone, Shofu, Tokyo, Japan) and converted to a wax pattern by pouring melted inlay wax into the mould to replicate the prepared abutment. After sprueing, investing, and casting with routine conventional standard methods, a suitably well-prepared abutment model for a full cast crown of the first premolar abutment in metal (Lucualloy; GC, Tokyo, Japan) was obtained. Finally, the abutment model was installed on the three-dimensional manipulating table (3-D manipulator K116M; Kyowa Riken, Tokyo, Japan).

The second step was to make samples to assess. In this study, we selected two kinds of attachment for each type of precision attachment (Cendres & Metaux SA, Biel-Bienne, Switzerland). The intracoronal attachments were a cylindrical slide and the dovetail slide beyeler. The extracoronal attachments were the Spang Stabilex and the Mini SG. The Mini SG has three kinds of plastic inserts (red, green, blue) for different retention requirements that were also assessed. The CCT was used as the control. The shapes and designs of the attachments are shown in Figure 1.

The crown portions were waxed using the plastic sheet technique (Adapta, Bego Co, Bremen, Germany) and preformed wax patterns for crown casting were used (preformed wax pattern M33, Nissin) to give the samples a standard size and shape. Next, the male or female part of the attachments were connected to the waxed portion of the crowns with the paralleling mandrill on the parallelometer, after which investing and casting were performed using routine conventional standard methods with dental casting alloy (Castwell M.C. 12% gold alloy, G.C., Tokyo, Japan) according to the manufacturer's instructions. After finishing the crown portion casting, standard sized foot portions (15 mm long, 4 mm wide, and 4 mm thick) were fabricated on the installed metal abutment with the paralleling mandrill on the parallelometer. The foot portion was completed

Figure 1. *Precision attachments assessed in this study. Left to right: conical crown telescope, cylindrical slide, dovetail slide beyeler, Spang Stabilex, and Mini SG.*

using conventional standard casting methods to finish the samples (Figure 2).

Two displacement transducers (both 9E08-D1-10, Nichiden-Sanei Electronic Instruments Inc, Tokyo, Japan) were fixed in the 3-D manipulating table to measure the mesial and distal end displacements of the samples. Force was applied using an electronic output tension meter (based on the tension meter, Haldex AB, Halmstad, Sweden) on the terminal end of the sample's foot portion. The electronic signals of the three apparatuses were amplified by dynamic strain amplifiers (6M82, Nichiden-Sanei Electronic Instruments Inc), recorded on a data recorder (MR30, Teac, Tokyo, Japan), and simultaneously monitored using a pen recorder (WR3310-8H, Graftec Inc, Tokyo, Japan) and output

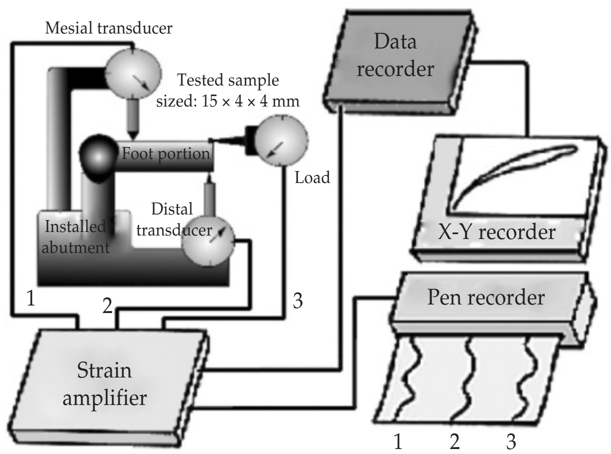

Figure 2. *Measurement apparatus setup.*

to an X-Y recorder (WX 2311, Graftec Inc) for graphing and calculation (Figure 2).

There were two loading directions with a load force controlled by the tension meter: the vertical direction was loaded with 1.5 kg of force and the horizontal direction was loaded with 1.0 kg of force (Figure 3). Measurements were repeated 10 times for vertical and five times for horizontal loading to decrease the possibility of technical error.

Results

After assessment, means and standard deviations for each attachment and loading were obtained. Mesial and distal end displacements are shown in Table 1 and are plotted in Figures 4 and 5. One-way ANOVA revealed highly significant differences in displacements in vertical loading and horizontal loading among the different sample groups (both $p < 0.001$). Multiple comparisons were made between the two means using Scheffe's test (Tables 2–6).

Discussion

The largest mesial end displacements with vertical loading were obtained with the CCT, followed by the cylindrical slide, Mini SG, Spang Stabilex, and dovetail slide beyeler in sequence, but all these mesial end displacements were very small, within 3 μm. Clinical experience shows that the distal end displacement plays an important role. The largest distal end displacements with vertical loading were obtained with the Mini SG, followed by the cylindrical slide, dovetail slide beyeler, and Spang Stabilex sequentially; the CCT had the smallest distal end displacement (Table 1 and Figure 4).

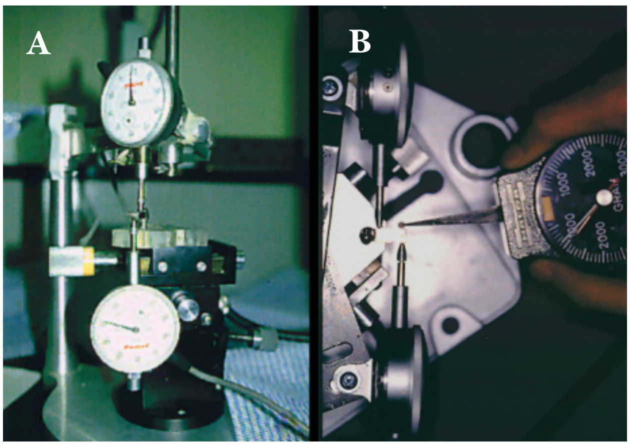

Figure 3. *Sample (A) vertically loaded and (B) horizontally loaded.*

The largest mesial end displacement when horizontally loaded was obtained with the dovetail slide beyeler, followed by the CCT, Mini SG, Spang Stabilex and cylindrical slide sequentially. Mesial end displacements with the dovetail slide beyeler were as large as 44.5 μm, while with the others, they were all below 16.5 μm. The same phenomena occurred with distal end displacements when horizontally loaded; the largest was obtained with the dovetail slide beyeler, followed by the Spang Stabilex, CCT, cylindrical slide, and Mini SG. Distal end displacements with the dovetail slide beyeler were as large as 75.2 μm, while those with the others were all below 31.2 μm. Distal end displacement with the dovetail slide beyeler was 2.4–3.4 times more than that with the other devices (Table 1 and Figure 5).

Physiologic tooth mobility is normally tested using a load of only 0.5 kg [3,6,15], when mobility of a premolar should be within 100 μm. In this study, all the testing loads were larger than 0.5 kg. Although there were statistically significant differences between the devices, all were within physiologic tooth mobility. The dovetail slide beyeler when horizontally loaded may be an exception, because the distal end displacement displayed some potential to entail danger.

The dovetail slide beyeler and cylindrical slide are the same type of intracoronal attachment, but their behavior is quite different when horizontally loaded. The reasons depend on the precise fit and contact surface area between the contacts of the male and female parts of the attachment. The contact surface of the cylindrical slide is 3.5 mm wide and 7.0 mm high, while the dovetail slide beyeler has a contact surface that is only 3.0 × 3.8 mm [16]. The contact area of the dovetail slide beyeler is smaller (46.5%) than that of the cylindrical slide, so when the dovetail slide beyeler or similar-sized attachments are used as a retainer, they should be reinforced with a bracing arm or stabilizer to resist the horizontal displacement force because of their weakness.

The Mini SG's retention is derived from plastic inserts: red gives normal friction, green gives medium friction and blue gives strong friction. When horizontally loaded, there were no statistically significant differences between them, but when vertically loaded, statistically significant differences were revealed.

To reiterate, this study's purpose was only to assess the connecting rigidity of various types of precision attachments, and should only be viewed from this standpoint. Other considerations of attachment applications not measured in this study include oral hygiene maintenance, the

Table 1. Mean ± standard deviation (μm) of the displacement in the experimental groups

Group	Vertical load (n = 10)		Horizontal load (n = 5)	
	Mesial end	Distal end	Mesial end	Distal end
Conical crown telescope	2.7 ± 1.3	9.8 ± 6.8	16.8 ± 2.4	27.9 ± 3.9
Dovetail slide beyeler	0.2 ± 0.1	12.7 ± 0.4	44.5 ± 7.0	75.2 ± 3.8
Cylindrical slide	2.5 ± 0.1	14.3 ± 0.4	11.4 ± 1.2	26.9 ± 3.9
Spang Stabilex	0.7 ± 0.4	10.5 ± 0.2	11.8 ± 2.1	31.2 ± 1.7
Mini SG (red plastic insert)	1.4 ± 0.2	21.4 ± 1.8	15.2 ± 4.7	20.7 ± 9.6
Mini SG (green plastic insert)	1.2 ± 0.1	17.6 ± 0.8	10.2 ± 1.0	22.1 ± 0.8
Mini SG (blue plastic insert)	1.0 ± 0.1	17.5 ± 0.3	9.9 ± 1.0	21.9 ± 0.6

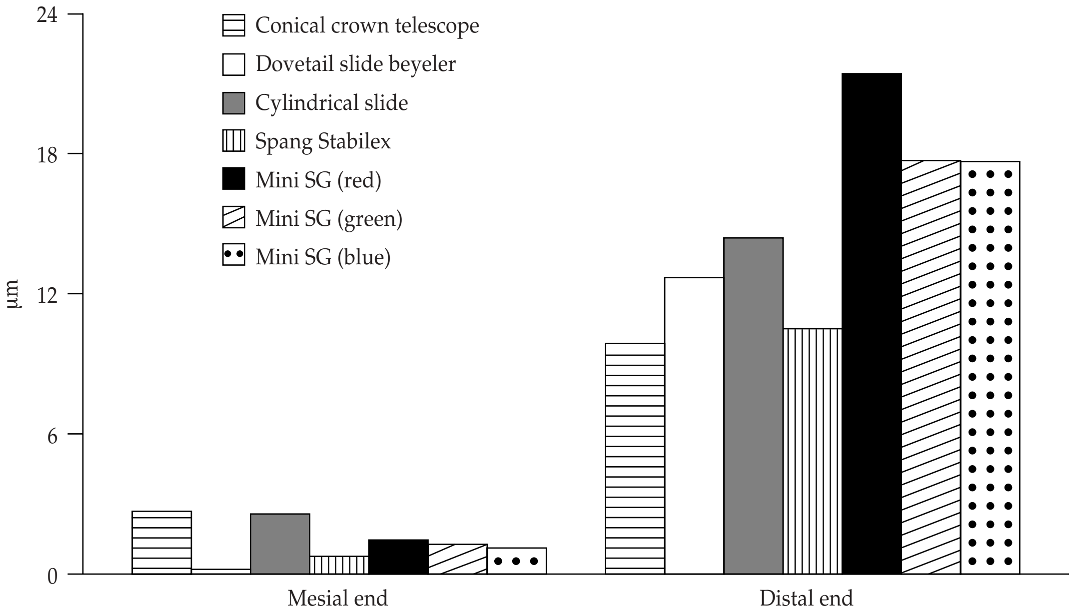

Figure 4. *Mesial end and distal end displacements of samples when vertically loaded (1.5 kgf).*

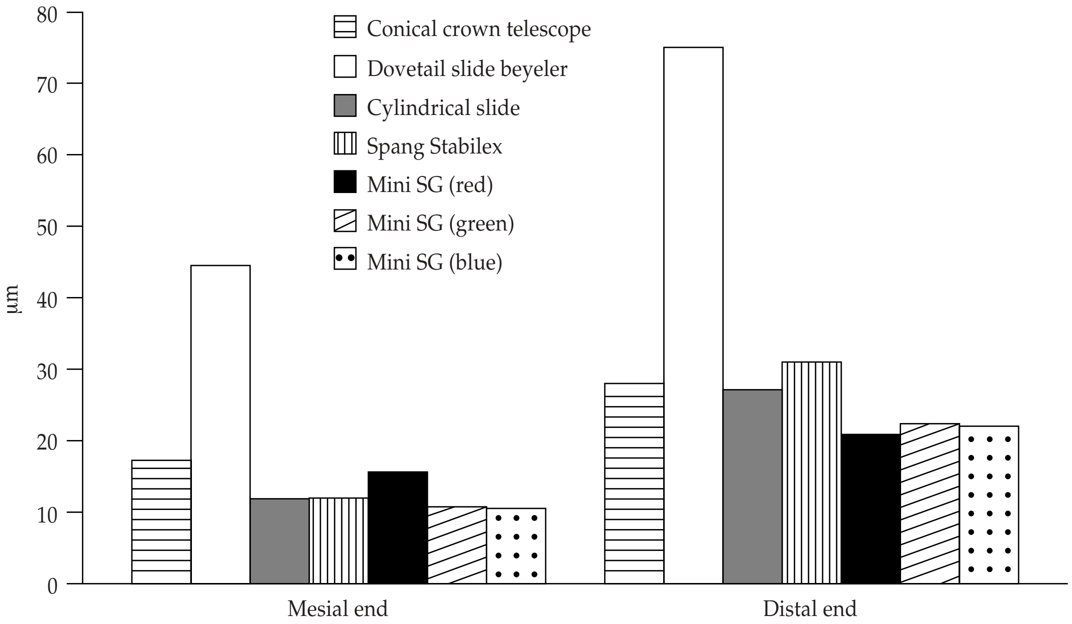

Figure 5. *Mesial end and distal end displacements of samples when horizontally loaded (1.0 kgf).*

Table 2. One-way ANOVA of mesial end displacements when vertically loaded

	Sum of squares	DF	Mean square	F	Significance of F
Among groups	43.39	6	7.25	11.41	0.000
Error	32.39	51	0.64		
Total	75.88	57			

Table 3. One-way ANOVA of distal end displacements when vertically loaded

	Sum of squares	DF	Mean square	F	Significance of F
Among groups	919.15	6	153.19	13.78	0.000
Error	544.85	49	11.12		
Total	1464.00	55			

Table 4. One-way ANOVA of mesial end displacements when horizontally loaded

	Sum of squares	DF	Mean square	F	Significance of F
Among groups	4566.84	6	761.14	49.76	0.000
Error	428.32	28	15.30		
Total	4995.16	34			

Table 5. One-way ANOVA of distal end displacements when horizontally loaded

	Sum of squares	DF	Mean square	F	Significance of F
Among groups	11156.15	6	1859.36	73.59	0.000
Error	707.49	28	28.27		
Total	11863.64	34			

Table 6. Scheffe's test for displacement in the experimental groups

Group	Vertical load		Horizontal load	
	Mesial end	Distal end	Mesial end	Distal end
Conical crown telescope	A	A	A	A
Dovetail slide beyeler	B	AB	B	B
Cylindrical slide	AC	AC	AC	AC
Spang Stabilex	D	AD	C	ACD
Mini SG (red plastic insert)	E	E	AC	ACDE
Mini SG (green plastic insert)	F	F	C	CE
Mini SG (blue plastic insert)	D	F	C	CE

Groups marked with the same letter are not significantly different ($p > 0.05$).

clinical crown length of the abutment tooth, ridge shape, arch form, repair and wear problems [17], space for artificial tooth arrangement, and even the intermaxillary space; these should also be carefully considered when such an attachment is anticipated.

References

1. Sekone H, Kishi M. Biomechanics of removable partial dentures. *Nippon Shika Hyoron* 1981;Suppl:37–53. [In Japanese]
2. Igarashi Y. Free-end saddle partial denture rigidly supported by the abutments. Part 1: functional stress of the abutments.

J Jpn Prosthodont Soc 1982;26:1014–20. [In Japanese]
3. Körber KH. Dynamic mechanisms of periodontium and denture tissue structure under loading *Dtsch Zahnarztl Z* 1983; 38:975–85. [In German]
4. Igarashi Y. Analysis of the denture dynamics in RPDs. Part 2: influence of retainers on the dynamics of free-end saddle. *J Jpn Prosthodont Soc* 1990;34:128–35. [In Japanese]
5. Igarashi Y, Kawata M, Shiba A. In vivo assessment of the occlusal stress distributed in the free-end saddle RPDs. *J Dent Res* 1991;70:793.
6. Igarashi Y, Ogata A, Kuroiwa A, et al. Stress distribution and abutment tooth mobility of distal extension removable partial dentures with different retainers: an in vivo study. *J Oral Rehabil* 1999;26:111–6.
7. Ogata A. In vivo assessment of occlusal stress distribution in free-end saddle removable partial dentures. Part 2: connecting rigidity affecting the stress distribution in free-end saddle removable partial dentures. *J Jpn Prosthodont Soc* 1998;42:393–401. [In Japanese]
8. Körber KH. *The Conical Crown Telescope.* Heidelberg: Hüthig, 1969.
9. Igarashi Y, Goto T. Ten-year follow-up study of conical crown-retained dentures. *Int J Prosthodont* 1996;10:149–55.
10. Wenz HJ, Hertrampf K, Lemann KM. Clinical longevity of removable partial dentures retained by telescopic crowns; outcome of the double crown with clearance fit. *Int J Prosthodont* 2001;14:207–13.
11. Shiba A. *The Conical Double-Crown Telescopic Removable Periodontic Prosthesis.* St. Louis: Ishiyaku EuroAmerica, 1993.
12. Preiskel HW. *Precision Attachments in Dentistry.* London: Henry Kimpton, 1968.
13. Baker JL, Goodkind RJ. *Theory and Practice of Precision Attachment Removable Partial Dentures.* St. Louis: Mosby, 1981.
14. Igarashi Y, Kawata M, Asami M, et al. The connecting rigidity between abutment teeth and retainers in RPDs. Part 1: the connecting rigidity in various clasp retainers. *J Jpn Prosthodont Soc* 1990;34:1162–9. [In Japanese]
15. Igarashi Y, Ai M. Free-end saddle partial denture rigidly supported by the abutments. Part I: functional stress of the abutments. *J Jpn Prosthodont Soc* 1982;26:1014–20. [In Japanese]
16. *Attachments for Prosthetic Dentistry.* Manual of Cendres & Metaux SA Co.
17. Wichmann MG, Kuntze W. Wear behavior of precision attachments. *Int J Prosthodont* 1999;12:409–14.

精密附連體與錐形冠套疊式義齒連結強度的評估與比較

王兆祥[1]　李惠娥[1]　杜哲光[1]　五十嵐順正[2]

[1]高雄醫學大學 附設醫院 牙科　[2]日本松本齒科大學 第一補綴學教室

本研究是觀察數種強固支持的精密附連體的連結強度，並和錐形冠套疊式義齒來比較。結果顯示各組之間雖然存在有許多統計意義差別，然而垂直施力時近心及遠心的位移都很小 (近心小於 **3.0 μm**，遠心小於 **21.4 μm**)。水平施力時近心及遠心的位移都各組都很接近，只有**dovetail slide beyeler**卻是很大差距，近心的位移為 **44.5 μm** (其他組皆小於 **16.5 μm**)，遠心的位移高達 **75.0 μm** (其他組皆小於 **31.2 μm**)。可見得要用 **dovetail slide beyeler** 這一類的精密附連體來替代錐形冠套疊式義齒時，在垂直上雖然沒有問題，在水平方向卻是弱點，必須增設抱持臂 (**bracing arm**) 來抵抗水平所造成的變位。

關鍵詞：連結強度，精密附連體，錐形冠套疊式義齒，遠心端游離局部活動義齒

（高雄醫誌 **2005;21:22–8**）

收文日期：**93** 年 **2** 月 **19** 日
接受刊載：**93** 年 **12** 月 **15** 日
通訊作者：杜哲光醫師
高雄醫學大學附設醫院牙科
高雄市三民區自由一路 **100** 號