In Vitro Cyclic Dislodging Test on Retentive Force of Two Types of Female Parts of SFI-Bar

Ling Wei, DDS[1]/Qinwei Ma, PhD[2]/Xiaotong Qin, MSc[3]/Shaoxia Pan, DDS, PhD[4]

Purpose: This study aimed to compare the difference in mechanical behavior between two types of female-part clips of the Stress-Free Implant Bar (SFI-Bar) system during simulation of insertion–removal cycles. ***Materials and Methods:*** A total of 10 samples simulating SFI-Bar-attachment-retained implant overdentures were fabricated and randomly divided into two groups (n = 5). One group used E-clips (Elitor alloy) as the female part of the SFI-Bar, and the other used T-clips (all titanium grade IV with red nylon inserts). A total of 14,000 insertion–removal cycles were carried out on each sample. Retentive forces from each cycle were recorded for analysis. ***Results:*** Significant differences were found between the two groups ($P < .05$). ***Conclusion:*** The retentive force of E-clips increased as the number of dislodging cycles increased, suggesting that some adjustment may be needed to lower this part's retentive force. T-clips with changeable nylon inserts were deformed after about 4,200 insertion–removal cycles, which interfered with insertion. This indicated that T-clips may need replacement after 2 to 3 years of clinical use. *Int J Prosthodont 2016;29:293–295. doi: 10.11607/ijp.4769*

Implant overdentures have been proven to be superior to conventional dentures in restoring the edentulous mandible.[1,2] Compared with various unsplinted attachments (eg, Locator attachments, ball attachments), bar-clip attachments can transmit vertical loads more effectively to supporting implants.[3] Stress-Free Implant Bar (SFI-Bar, Cendres+Métaux) is a modular system that connects implants with no soldered or laser-welded joints, and this allows fabrication of a passive-fit bar and clip system on two or more implants. There are two designs for the female part of SFI-Bar, the E-clips (Elitor precious metal alloy) and the T-clips (all titanium grade IV with nylon inserts). The aim of this in vitro study was to compare the difference in mechanical behavior of the two female clips during simulation of insertion–removal cycles.

[1]*Graduate Student, Department of Prosthodontics, Peking University School and Hospital of Stomatology, Beijing, China.*

[2]*Professor, Department of Mechanics, School of Aerospace Engineering, Beijing Institute of Technology, Beijing, China.*

[3]*Associate Professor, Department of Mechanics, School of Aerospace Engineering, Beijing Institute of Technology, Beijing, China.*

[4]*Associate Professor, Department of Prosthodontics, Peking University School and Hospital of Stomatology, Beijing, China.*

Correspondence to: *Dr. Shaoxia Pan, Associate Professor, Department of Prosthodontics, Peking University School and Hospital of Stomatology, No. 22 Zhongguancun South Avenue, Haidian District, Beijing 100081, China. Fax: (8610) 6217 3402. Email: sx_pan@hotmail.com*

Materials and Methods

Ten pairs of custom-made polymethylmethacrylate (PMMA) blocks mimicking part of the anterior edentulous mandible (patrix) and counterpart (matrix) implant overdenture using SFI-Bar-attachments (Cendre + Metaux) were fabricated. One of each pair of blocks was embedded with two parallel implants (4.1 × 10 mm RNSP, Straumann) connected via SFI-Bar. The samples were randomly divided into two groups of five pairs each. In one group, E-clips were used as the female part; in the other, T-clips were used. The female part was connected to the matrix using autopolymerized acrylic resin. To ensure precise insertion, all clips were bonded to the matrices after calibration on the testing system.

The testing was carried out on a static/dynamic electrical servo-hydraulic fatigue material testing system (MTS 810, MTS Systems). The patrix and matrix were fastened to the lower and upper elements of the testing device, respectively. Retentive forces were recorded in each cycle during the total 14,000 insertion–removal cycles for each pair of models (Fig 1).

Two-way analysis of variance followed by Student-Newman-Keuls test were conducted for statistical analysis.

Results

The initial mean retentive force of E-clips (27.81 ± 7.90 N) was higher than that of T-clips with three red nylon inserts (22.78 ± 2.94 N) ($P < .01$). Throughout

Fig 1 *(left)* Insertion–removal cycles were repeated on the testing system and retentive forces were simultaneously recorded.

Fig 2 *(below)* Comparison of retention forces between E-clips and T-clips.

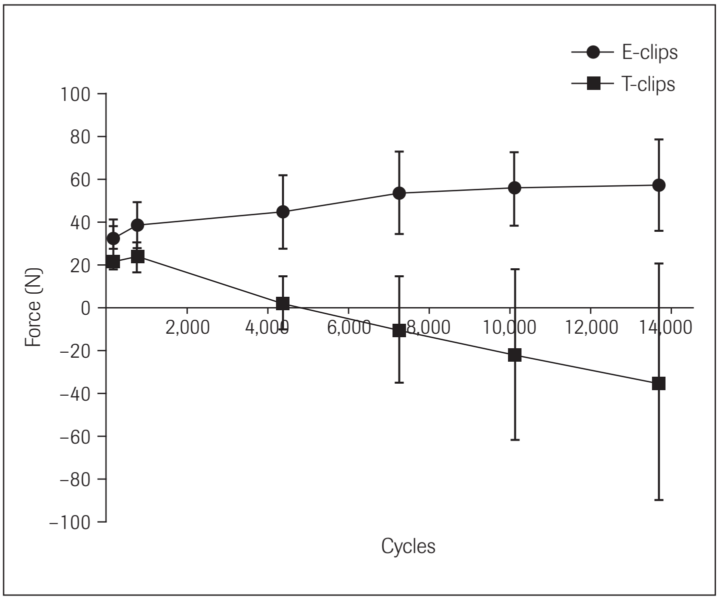

Table 1 Mean Retention Values (in N) and Standard Deviations (SD) for E-Clips And T-Clips Recorded in Dislodging Cycles

	Group	
Cycles (n)	E-clips	T-clips
10	27.8 ± 7.9	22.8 ± 2.9
120	31.7 ± 10.0	23.2 ± 4.3
720	38.3 ± 11.4	23.4 ± 6.3
4,320	44.9 ± 16.9	2.2 ± 12.1
7,200	53.4 ± 19.2	−10.4 ± 24.7
10,080	55.4 ± 17.4	−21.5 ± 39.9
13,680	57.8 ± 21.4	−34.5 ± 55.1

the test, the mean retentive force of the E-clips increased as the number of dislodging cycles increased. The mean retentive force of the T-clips remained steady during the first 720 cycles, then started to decrease (Fig 2). At the end of 4,200 cycles, the retentive force in the T-clips group reached zero and then became negative (pressure). Afer 13,680 cycles, the retentive force of E-clips increased to 57.82 ± 21.35 N, while that of T-clips decreased to −34.54 ± 55.07 N (Table 1).

Discussion

In this study, 14,000 cycles were performed to simulate the insertion–removal process of implant overdentures during 9.5 years in vivo based on an average of four insertion–removals per day.

According to some studies,[4–6] the minimum retentive strengths from 8 N to 20 N were sufficient to retain and stabilize an overdenture. This study showed that the initial mean retentive force of E-clips and T-clips were 27.81 ± 7.90 N and 22.78 ± 2.94 N, respectively, meaning that both types of clips displayed satisfactory retentive strength.

The retention ascent of E-clips during the experiment can be explained by complex tribologic interaction in metal-to-metal contacts. The surfaces of the E-clips showed increased roughness as insertion–removal cycles went on.[7] These findings were in accordance with Pigozzo's study reporting an increase in retentive strength during 5,500 insertion–removal cycles.[8]

For the T-clips with changeable nylon inserts, a continuous loss of retentive force after 720 cycles was detected. At the end of 4,200 cycles, the retentive force manifested as negative, demonstrating that the direction of retentive force changed from tensile to compressive. This resulted in dislodgement of denture and was attributed to the plastic deformation of nylon inserts that tend to deviate from the titanium shell or be prone to automatically popping out. The present study showed that nylon inserts in T-clips may develop deformation after 2 to 3 years of clinical use and should be changed accordingly.

This study did not consider the effect of saliva wetting, and therefore the results may differ from the situation in reality.

Conclusions

Within the limitations of this study, it can be concluded that for the SFI-bar system, the retentive force of E-clips increased as the number of dislodging cycles increased, and some adjustment may be needed from time to time to lower retention. Nylon inserts in T-clips may show deformation and interfere with the insertion after 2 to 3 years of clinical use and should be changed accordingly.

Acknowledgments

The authors reported no conflicts of interest related to this study.

References

1. Pan S, Dagenais M, Thomason JM, et al. Does mandibular edentulous bone height affect prosthetic treatment success? J Dent 2010;38:899–907.
2. Batenburg RH, Meijer HJ, Raghoebar GM, Vissink A. Treatment concept for mandibular overdentures supported by endosseous implants: A literature review. Int J Oral Maxillofac Implants 1998;13:539–545.
3. Naert I, Alsaadi G, Quirynen M. Prosthetic aspects and patient satisfaction with two-implant-retained mandibular overdentures: A 10-year randomized clinical study. Int J Prosthodont 2004;17:401–410.
4. Jia A, Xu M, Zhang W, et al. Study on retention force of dentures with various retention devices on models. J Clin Stomatol 2003;19:229–230.
5. Petropolulos V, Kousvelari E, Smith W. A comparative study on the retention of implant overdenture attachments. J Dent Res 1996;75:184–189.
6. Bessimo CE, Guarnieri A. In vitro retention force changes of prefabricated attachments for overdentures. J Oral Rehabil 2003;30:671–678.
7. Kobayashi M, Srinivasan M, Ammann P, et al. Effects of in vitro cyclic dislodging on retentive force and removal torque of three overdenture attachment systems. Clin Oral Implants Res 2014;25:426–434.
8. Pigozzo MN, Mesquita MF, Henriques GE, Vaz LG. The service life of implant-retained overdenture attachment systems. J Prosthet Dent 2009;102:74–80.