Evaluation of the Retentive Force of a β-type Ti-6Mo-4Sn Alloy Wire Clasp

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The retentive force of a wire clasp composed of a β-type Ti-6Mo-4Sn alloy (β-Ti alloy) with a low Young modulus was evaluated using a piezoelectric transducer to determine the appropriate undercut for removable partial dentures. There were no significant differences in retentive force between a β-Ti alloy wire with a 0.50-mm undercut and a cobalt-chromium alloy (Co-Cr alloy) wire with a 0.25-mm undercut, or between a β-Ti alloy wire with a 0.75-mm undercut and a Co-Cr alloy wire with a 0.50-mm undercut. The β-Ti alloy wire may be applicable for abutment teeth with a large number of undercuts. *Int J Prosthodont 2010;23:38–41.*

Various metallic materials have been used to fabricate the clasps of removable partial dentures (RPDs) and the physical properties of these materials have been examined.[1,2] Recently, a β-type Ti-6Mo-4Sn alloy (β-Ti alloy) wire with a low Young modulus and a high elastic limit and biocompatibility was developed (see Table 1). The β-Ti alloy yields the most favorable use for RPD wire clasps because of its physical properties. Considering its use as a clasp, it is important to determine an appropriate amount of undercut based on the mechanical characteristics of the alloy for good retaining performance.[3,4] However, there is little data concerning the relationship between the retentive force and the indicated amount of undercut for β-Ti alloy wire, so no guidelines have been established for its clinical application.

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This study aimed to compare the retentive forces of β-Ti alloy wires and those composed of a cobalt-chromium alloy (Co-Cr alloy), a common metal for RPD wire clasp fabrication, to determine the appropriate amount of undercut when using β-Ti alloy wire for the wire clasp of an RPD.

Materials and Methods

β-Ti alloy wire (Neo-Titanium Wire, Yamahachi Dental) and Co-Cr alloy wire (Sun-Cobalt Clasp-Wire, Dentsply) were evaluated in this study. Seven wire clasps were bent along the abutment as a single-arm clasp for each β-Ti alloy and Co-Cr alloy, each with a different undercut depth (0.25, 0.50, and 0.75 mm). In total, 42 wire clasps were used.

A piezoelectric force transducer (Z18400, Kistler Instruments) was used to measure retentive force. The transducer contained three crystals in a steel housing unit to measure the forces three-dimensionally.[5] A force-measuring device consisting of the transducer and a stainless steel spherical abutment cast was developed (Fig 1). The device enabled measurement of the vertical and lateral forces exerted along the coordinates, determined by the pressure receiver of the transducer when the bent wires were removed from the abutment using a universal testing machine (Fig 2). The measurements were performed three times to determine the reprehensive retentive force of the clasp. Statistical comparisons were performed using the Kruskal-Wallis and Dunn tests.

Fig 1 *(right)* Schematic of the force-measuring device. The abutment and transducer were joined to the brass substructure with a screw.

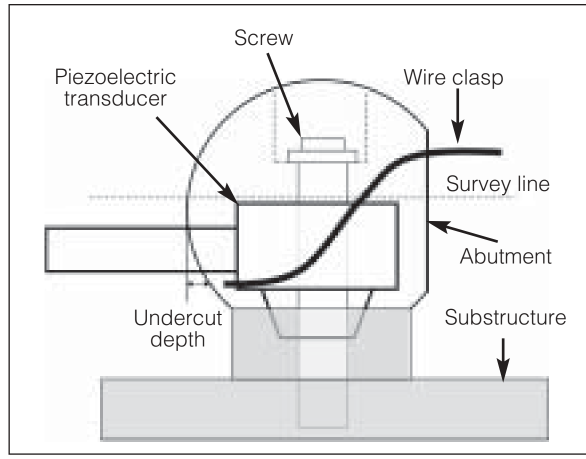
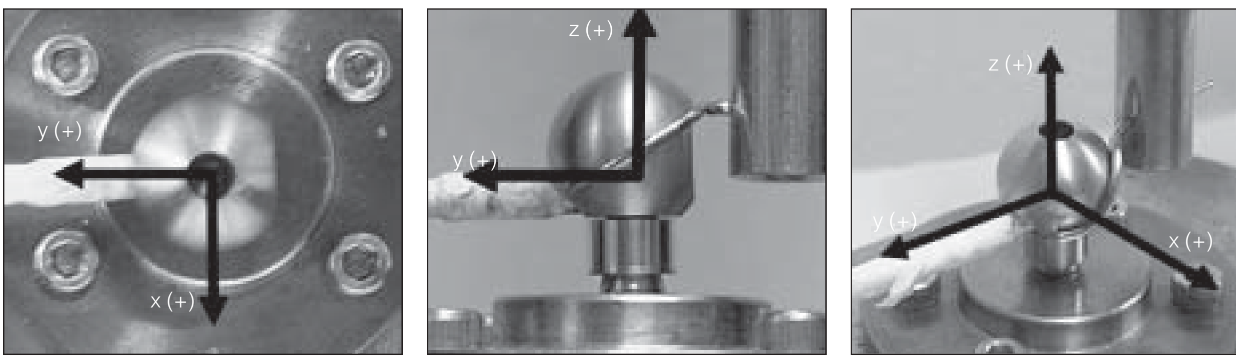


Fig 2 *(below)* Coordinates used for the analysis. The x- and y-axes run parallel to and the z-axis perpendicular to the pressure receiver of the transducer. A tested clasp was aligned along the y-axis and was removed upward along the z-axis. The positive direction of the x-axis is the side of the abutment with the clasp and the positive direction of y-axis is the side with the clasp tip. The positive direction of the z-axis is the upwards direction.



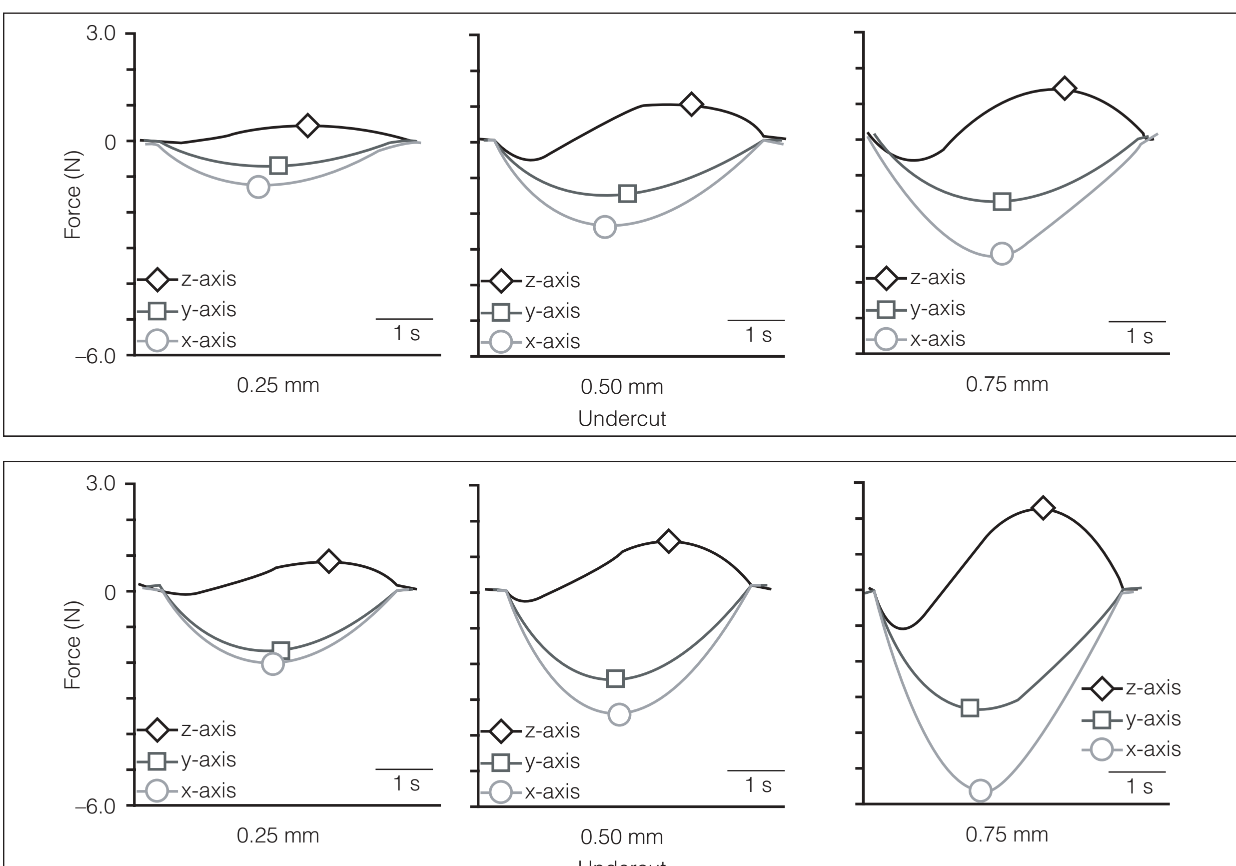
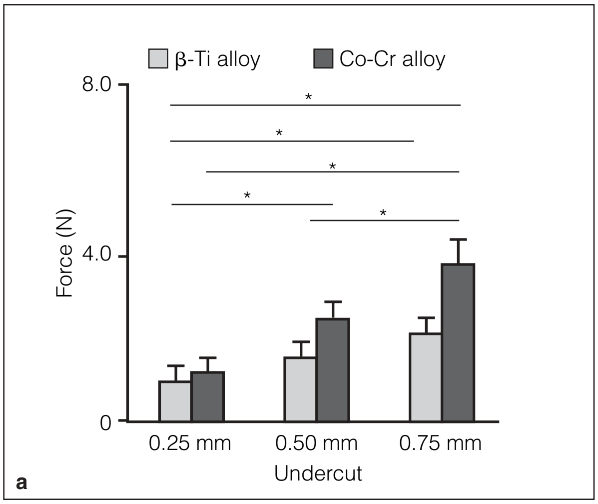
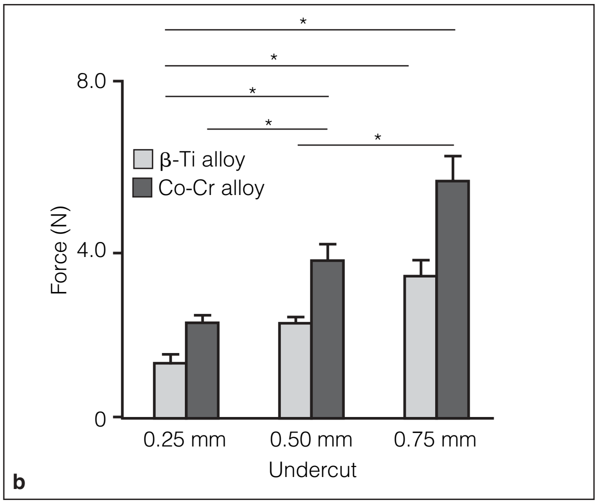


Fig 3 Force data examples of the **(top row)** β-Ti alloy wire and **(bottom row)** Co-Cr alloy wire.





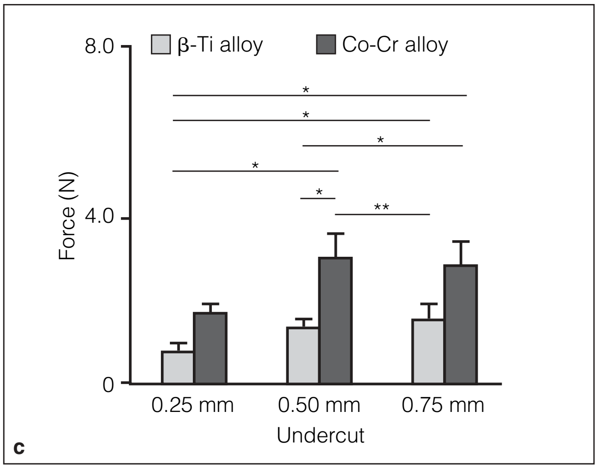


Fig 4a The maximum magnitude of the retentive force exerted on the abutment (z-axis). $*P < .01$.

Figs 4b and 4c The maximum magnitude of the lateral force exerted on the abutment. **(b)** x-axis and **(c)** y-axis. $*P < .01$, $**P < .05$.

Results

The forces on three orthogonal axes were recorded when the clasps were removed by the universal testing machine (Fig 3). Figure 4a shows the maximum magnitude of the force on the z-axis, regarded as the retentive force of the clasp. The retentive force of the β-Ti alloy wire was smaller than that of the Co-Cr alloy wire, although the difference was not significant when compared among wires using the same undercut values. There were no significant differences in the retentive force between the β-Ti alloy wire with 0.50-mm undercut and the Co-Cr alloy wire with 0.25-mm undercut, or between the β-Ti alloy wire with 0.75-mm undercut and the Co-Cr alloy wire with 0.50-mm undercut. Figures 4b and 4c show the maximum magnitudes of the lateral forces (the x- and y-axes). There were no significant differences between the β-Ti alloy wire with 0.50-mm undercut and the Co-Cr alloy wire with 0.25-mm undercut on either axis.

Discussion

The difference in the retentive force between the clasps of β-Ti alloy wire and Co-Cr alloy wire was thought to be caused by differences in the Young modulus (Tables 1a and 1b).[1,2] The retentive force exerted by the β-Ti alloy wire clasp with a larger undercut is comparable with that of the Co-Cr alloy wire clasp with a conventional undercut. In addition, the lateral force generate

Table 1a Elemental Composition and Mechanical Properties of Wire Materials

	Trade name	Element (wt%) Titanium	Molybdenum	Tin	Cobalt	Chromium	Nickel	Tungsten	Other	Mechanical properties Young modulus (GPa)	Elastic limit (GPa)	Tensile strength (MPa)	Elongation (%)
Ti-6Mo-4Sn	Neo-Titanium wire, Yamahachi	80.5	10.8	8.7	–	–	–	–	–	58	–	900	18
Co-Cr	Sun-Cobalt Clasp-wire, Denstply	–	3.0	–	46.0	20.0	22.0	3.0	6.0	157	740	981	1

Table 1b Elemental Composition and Mechanical Properties of Clasp Materials*

	Trade name	Element (wt%) Gold	Platinum	Silver	Copper	Palladium	Titanium	Niobium	Aluminum	Other	Mechanical properties Young modulus (GPa)	Elastic limit (GPa)	Tensile strength (MPa)	Elongation (%)
Ti-6Al-7Nb	T-Alloy Tough, GC	–	–	–	–	–	86.5	7.0	6.0	0.5	123	–	950	5
Type IV gold	Degulor M, Degusa	70.0	4.4	13.5	8.8	2.0	–	–	–	1.3	90	–	740	17

*Other clasp alloys are presented for the sake of comparison as the reference value of the mechanical properties.

by the β-Ti alloy wire clasp with a larger undercut was also similar to that of the Co-Cr alloy wire clasp with a conventional undercut. Therefore, the β-Ti alloy wire would be indicated for abutment teeth with a larger undercut. Furthermore, β-Ti alloy wire is thought to be advantageous for partially edentulous patients who have a metal allergy due to its biocompatibility.

Conclusion

RPD wire clasps made of β-Ti alloy wire are applicable for abutment teeth with relatively large undercuts.

References

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