

Mechanical Evaluation of Long Titanium Alloy Clip —Comparison of Cobalt Alloy Clip

Tetsuyoshi HORIUCHI,¹ Kiyoshi ITO,¹ Kazuhiro HONGO,¹ and Masato SHIBUYA²

¹*Department of Neurosurgery, Shinshu University School of Medicine, Matsumoto, Nagano;*

²*Department of Neurosurgery, Chukyo Hospital, Nagoya, Aichi*

Abstract

Long titanium aneurysm clips have recently been released. In the present study, comparative study of long titanium and cobalt alloy clips was performed. Two kinds of Sugita long clips (straight clips of 25- and 35-mm blade length) made of titanium and cobalt alloys were tested by measuring the closing force, the anti-scissoring torque, and the maximum opening width. There were some differences between the two materials. In the 25-mm blade length clip, closing force and maximum opening width of titanium alloy clip were greater than those of cobalt alloy clip. By contrast, the anti-scissoring torque of 35-mm blade length titanium clip was stronger than that of the cobalt. The long titanium clips would have equivalent endurance to long cobalt clip and are safe for clinical use.

Key words: aneurysm, aneurysm clip, instrumentation, titanium

Introduction

Direct surgical treatment of giant cerebral aneurysm and/or complex aneurysm requires special instrumentations such as long blade clips of over 20 mm.^{1,2)} Although titanium aneurysm clips result in significant improvement of imaging on computed tomography and magnetic resonance imaging compared to traditional cobalt alloy clips,^{2,3)} long clip made of titanium alloy had not been available because titanium alloy comparing with cobalt alloy is not easily manufactured. Recently, long straight titanium clips (25- to 40-mm blade length) were released from Mizuho Co., Ltd., Tokyo (Fig. 1). In this study, mechanical characteristics of Sugita long clips were compared between cobalt and titanium alloys.

Materials and Methods

I. Aneurysm clips

Sugita long clips made of cobalt and titanium alloys (Mizuho Co., Ltd., Tokyo) were examined. Titanium alloy contains aluminum and vanadium (Titanium-6A1-4V). In the present study, two types of long clips made of titanium or cobalt alloy (Fig. 1, Table 1) were used and compared. There are some

differences in clip head and blade width between titanium and cobalt alloy clips although blade lengths are same (Fig. 1). All clips were kindly donated by Mizuho Co., Ltd., Tokyo. Currently, no Yasargil long titanium clips (over 20-mm blade length) are available. Therefore, comparative study between Sugita and Yasargil clips was not performed.

II. Mechanical clip evaluation

We measured closing forces, anti-scissoring torques, and opening widths of aneurysm clip and compared them between materials. A clip closing forcemeter⁴⁾ previously described was used to measure along clip blades in 3.0-mm increments. Blade separation distance was set at 1.0 mm. Anti-scissoring was evaluated to check torque value during clip twisting.⁵⁾ Torque measurement has been previously reported in detail.⁵⁾ Briefly, torque value of clip blades was measured at clip head rotation with clipping at 3-mm depth. Torque value represented anti-scissoring effect. Maximum opening widths were measured using the clip applicators.

III. Statistical analysis

All data were analyzed with the program PASW statistics 18 (SPSS Japan, Tokyo). Values were expressed as mean \pm standard deviation and *n* represents the number of used clips. Comparisons

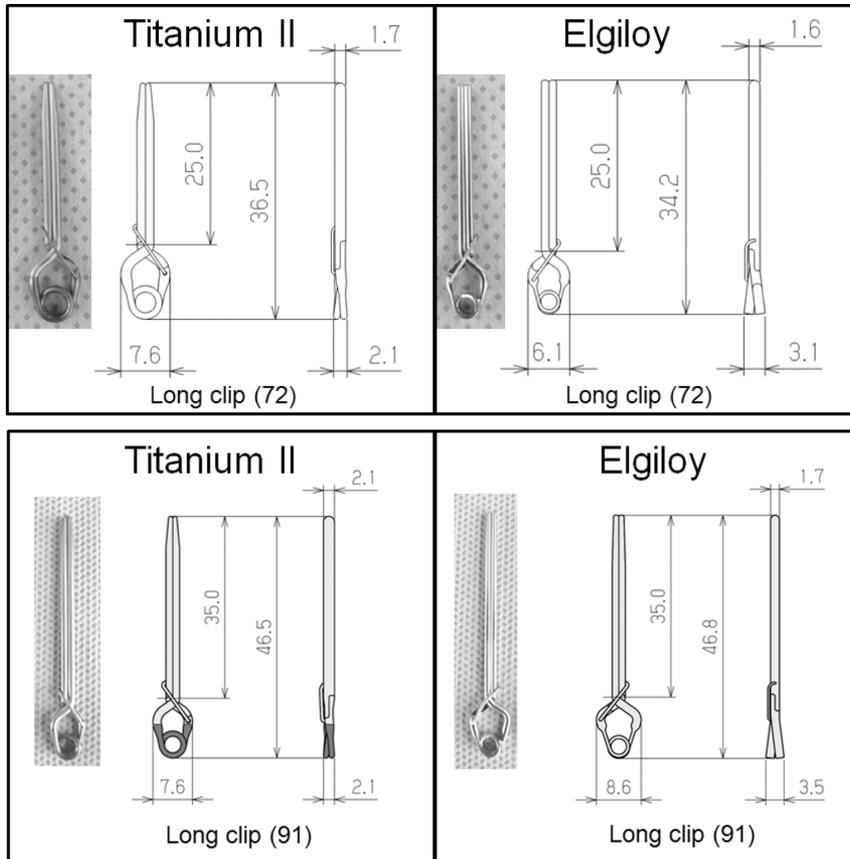


Fig. 1 Photographs and schematic drawings show titanium (17-001-72 and 17-001-91) and cobalt long clips (07-940-72 and 07-940-91).

Table 1 Characteristics of the aneurysm clips used in the present study

| Product name or material | Catalog number | Shape | Purpose | Blade length | Applied number |
|--------------------------|----------------|----------|-----------|--------------|----------------|
| Titanium II | 17-001-72 | Straight | Permanent | 25 | 5 |
| Elgiloy | 07-940-72 | Straight | Permanent | 25 | 5 |
| Titanium II | 17-001-91 | Straight | Permanent | 35 | 5 |
| Elgiloy | 07-940-91 | Straight | Permanent | 35 | 5 |

for continuous variables between two groups were made using unpaired *t* test. Differences were considered significant at $P < 0.05$.

Results

I. Closing force

The closing forces of long clips increased linearly from the tip of blades to the clip head (Fig. 2). Although 25-mm blade titanium clips had significantly greater closing forces than cobalt alloy clips (Fig. 2, *left*, $n = 5$), there were no differences in closing force of 35-mm blade clips between titanium and cobalt alloy (Fig. 2, *right*, $n = 5$).

II. Anti-scissoring torque

In a 25-mm blade clip, the torque values of both

alloy clips increased depending on rotation degree (Fig. 3A, $n = 5$). The cobalt alloy clip had significantly higher torque values than titanium clips. The torque value of 35-mm blade clip made of titanium, but not cobalt was directly proportional to clip head rotation (Fig. 3B, $n = 5$). In a 35-mm blade cobalt alloy clip, the torque value increased up to 60 degrees and decreased (Fig. 3B, $n = 5$). The torque of 35-mm blade titanium clip was significantly stronger than that of cobalt one over 50 degrees.

III. Maximum opening width

The opening widths of 25-mm blade titanium and cobalt clips were 16.5 ± 0.4 mm ($n = 5$) and 14.3 ± 0.8 mm ($n = 5$), respectively (Fig. 4, *upper column*). The difference was significant ($P < 0.001$). In 35-mm blade length clip, the opening width of

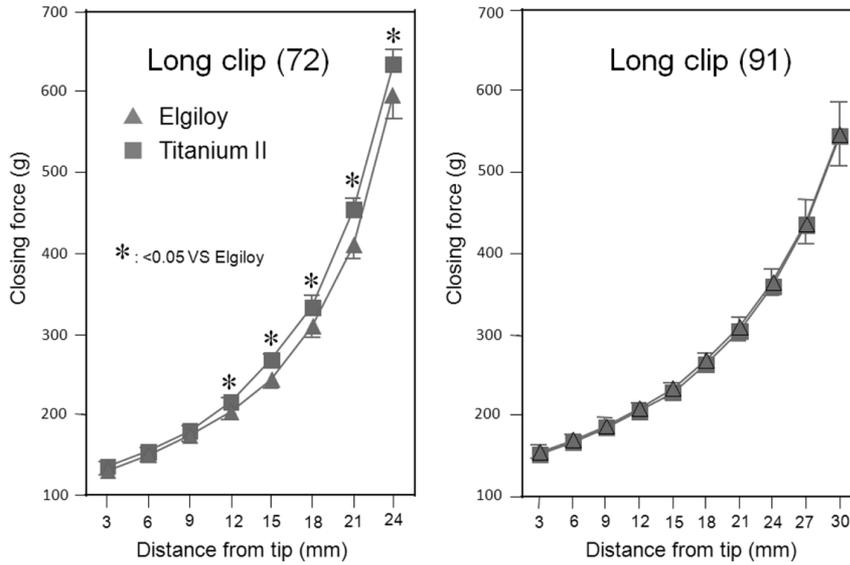


Fig. 2 Effect of distance from tip on Titanium II and Elgiloy closing forces. *Left*: 25-mm blade clip (17-001-72 and 07-940-72) and *right*: 35-mm blade clip (17-001-92 and 07-940-92). Asterisk indicates significant differences between Titanium II and Elgiloy.

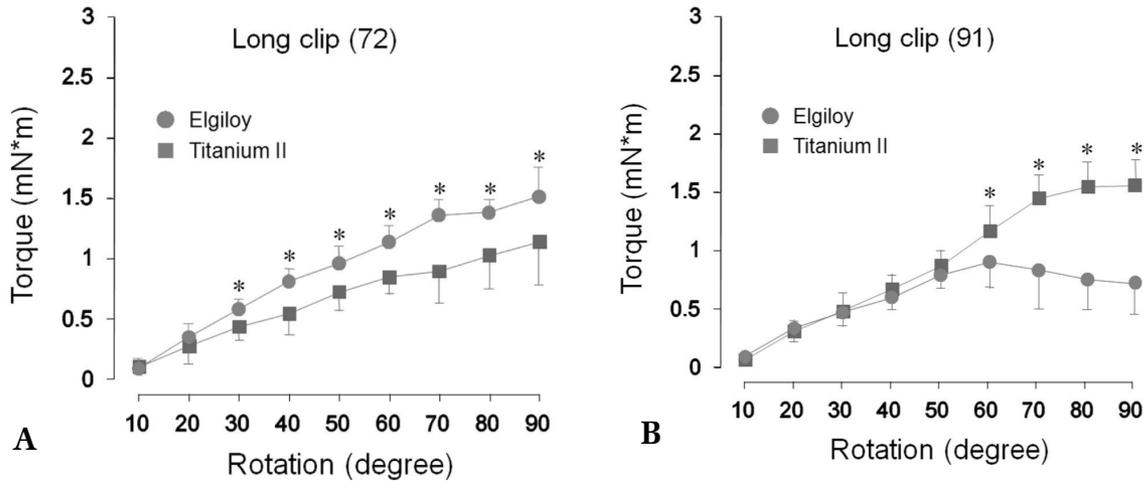


Fig. 3 Effects of torque value during Titanium II and Elgiloy clip head rotations. A: 25-mm blade clip and B: 35-mm blade clip. Asterisk indicates significant differences between Titanium II and Elgiloy.

titanium clip was 18.9 ± 0.2 mm ($n = 5$) and that of cobalt clip was 20.3 ± 0.3 mm ($n = 5$) (Fig. 4, lower column). There was a significant difference between titanium and cobalt clips ($P < 0.001$).

Discussion

The present study would indicate that long straight titanium clips have equivalent mechanical endurance to cobalt clips and use of long titanium clips is safe in vascular surgery although there were some differences in closing force, anti-scissoring,

and opening width between titanium and cobalt alloy. In 25-mm blade length clip, closing force and maximum opening width of titanium alloy clip were greater than those of cobalt alloy clip. By contrast, the anti-scissoring torque of 35-mm blade titanium clip was stronger than that of cobalt.

Knowledge of the mechanical properties of long aneurysm clips is essential for the safe use for giant cerebral aneurysm and/or complex aneurysm. Previous studies indicated the titanium clips may be prone to scissoring,^{1,5-7} cobalt alloy clips have not had the intraoperative problem with scissoring.

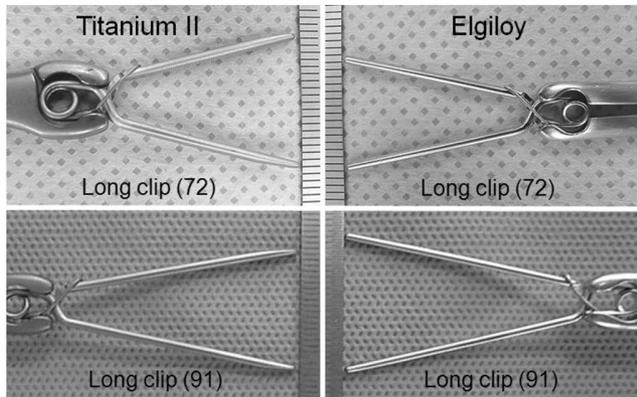


Fig. 4 Photographs show the maximum opening width. **upper column: 25-mm blade clip, and lower column: 35-mm blade clip.**

Recently, we evaluated the anti-scissoring property to measure the torque value during clip head rotation regarding standard sized clips.⁵⁾ In the present study, the anti-scissoring ability of 35-mm blade titanium clips was superior to that of cobalt clips. One of the possible explanations for this difference would be blade width and thickness of the blades in addition to material itself (Fig. 1).⁵⁾ The titanium clip blade width is thicker than the cobalt one.

Titanium clips were thought as having low closing force compared to cobalt clips.³⁾ However, our recent study⁴⁾ demonstrated that the closing force of Sugita standard titanium clip (Titanium II; the second-generation titanium clip) was stronger than that of cobalt clip. The present study of 25-mm blade clip was consistent with the previous study. On the other hand, there was no difference in the closing force of 35-mm blade clip between materials.

The opening width of the blade tip is one of the important characteristics to treat larger complex aneurysms. In the present study, the maximum opening width also varied on clip types because the maximum opening width depended on the clip head size. The clip head sizes of both titanium clips are same in Fig. 1A and B, although that of cobalt clips is different.²⁾ The large clip head can allow wider opening. However, large clip head might be a hindrance during clipping procedure.

There is a limitation to the present study. No comparison of Sugita and Yasargil long titanium clips are made because no Yasargil long titanium clips (over 20-mm blade length) are available.

Conclusion

We have examined and compared mechanical prop-

erties of long titanium clips made of titanium and cobalt alloys. Long titanium clips confer no major disadvantage over cobalt clips. They are safely used clinically.

Acknowledgment

This study was partly supported by JSPS KAKENHI Grant Number 25462251.

Conflicts of Interest Disclosure

No financial support was provided in the present study. Mizuho Co., Ltd. donated Sugita clips and lent the closing force-meter; however, the company did not have any role in data analysis, interpretation, or in writing this manuscript. We have no personal or institutional conflicts of interest.

References

- 1) Papadopoulos MC, Apok V, Mitchell FT, Turner DP, Gooding A, Norris J: Endurance of aneurysm clips: mechanical endurance of Yaşargil and Spetzler titanium aneurysm clips. *Neurosurgery* 54: 966–970; discussion 970–972, 2004
- 2) Sugita K, Kobayashi S, Inoue T, Takemae T: Characteristics and use of ultra-long aneurysm clips. *J Neurosurg* 60: 145–150, 1984
- 3) Nagatani T, Shibuya M, Ooka K, Suzuki Y, Takayasu M, Yoshida J: Titanium aneurysm clips: mechanical characteristics and clinical trial. *Neurol Med Chir (Tokyo)* 38(Suppl): 39–44, 1998
- 4) Horiuchi T, Rahmah NN, Yanagawa T, Hongo K: Revisit of aneurysm clip closing forces: comparison of titanium versus cobalt alloy clip. *Neurosurg Rev* 36: 133–137; discussion 137–138, 2013
- 5) Horiuchi T, Hongo K, Shibuya M: Scissoring of cerebral aneurysm clips: mechanical endurance of clip twisting. *Neurosurg Rev* 35: 219–224; discussion 224–225, 2012
- 6) Horiuchi T, Li Y, Seguchi T, Sato A, Aoyama T, Hanaoka Y, Hongo K: Clip blade scissoring with titanium bayonet clip in aneurysm surgery. Two case reports. *Neurol Med Chir (Tokyo)* 52: 84–86, 2012
- 7) Carvi y Nievas MN, Höllerhage HG: Risk of intraoperative aneurysm clip slippage: a new experience with titanium clips. *J Neurosurg* 92: 478–480, 2000

Address reprint requests to: Tetsuyoshi Horiuchi, MD, Department of Neurosurgery, Shinshu University School of Medicine, 3-1-1 Asahi, Matsumoto, Nagano 390-8621, Japan.
e-mail: tetuyosi@shinshu-u.ac.jp