Biocompatibility analysis of the Sundt-Kees booster clip and the Drake aneurysm clip

Technical note

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A combination of the Sundt-Kees reinforcing aneurysm clip applied to a Drake aneurysm clip in a piggyback fashion was studied for possible defects due to corrosion and tissue toxicity. These two clips, which are made of similar metal (301 stainless steel), showed little or no defects when immersed in 5% saline or when implanted in rats for 6 months. This study demonstrates that clips made of similar metals can be used piggyback in patients without ill effects provided that they are carefully handled to avoid any abrasion or misbends which could conceivably lead to corrosion.

KEY WORDS • reinforcing clip • aneurysm clip • corrosion • metallurgic study

The increasing use of aneurysm clips for giant and globular aneurysms has prompted the application of clips in tandem or piggyback fashion to increase the available jaw compression so as to avoid clip movement or slippage. When aneurysm clips are placed one on another there is a possibility of creating a series galvanic battery which could lead to corrosion and tissue toxicity at and around the area of contact. Numerous studies have addressed the effects of corrosion and tissue toxicity of different metals separately. This study was undertaken to investigate the effects of using these clips in piggyback fashion for signs of corrosion and tissue toxicity.

Materials and Methods

Phase I: In Vitro Studies

A Sundt-Kees reinforcing aneurysm clip was placed in piggyback fashion on a Drake aneurysm clip and immersed in a 5% saline-in-agar solution for 2 months. Prussian blue was added as a pH colorimetric visual indicator to demonstrate anodic ionization between the clips. Similarly, a Drake aneurysm clip was placed on a solid silver wire as a control and immersed in a separate solution with the pH indicator described above.

The clips were removed from the solution at the end of the 2-month period and color photographs were taken. The clips were then separated, prepared for scanning electron microscopy, and viewed at various magnifications at the site of contact and at control areas without contact.

Phase II: In Vivo Studies

Two sets of Sundt-Kees reinforcing aneurysm clips placed in piggyback fashion on a Drake aneurysm clip were implanted in the thigh area of two Sprague-Dawley rats. These rats were kept under observation for 6 months and then were sacrificed. The clips were removed and photographed in color. Scanning electron micrographs were taken before and after the clips were separated.

Results

Phase I: In Vitro Studies

Color photographs of the combination of the Sundt-Kees reinforcing clip placed on the Drake aneurysm clip showed no obvious metallic disturbance. However, there was marked corrosion of the Drake aneurysm clip that was attached to the silver wire due to the galvanic action between the 301 stainless steel and the solid silver. These findings are similar to those in a study by McFadden. The pH colorimetric indicator showed no
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Fig. 1. Scanning electron micrographs of a Drake aneurysm clip that was applied to a solid silver wire and placed in a saline bath. Note that the surfaces of the contact area are literally eaten away. Left: Overall view of the two prongs. Arrows show the area in contact with the silver wire. × 8. Center: View of the right prong at the contact area. × 48. Right: View of the left prong at the contact area. × 48.

apparent reaction between the two clips, but there was a slight blue colorization in the area of contact between the Drake aneurysm clip and the silver wire.

The Drake aneurysm clip used as a control showed a significant amount of corrosion on both jaws at the site of contact with the silver wire (Fig. 1 left). The right and left prongs showed the metal surface at the site of contact literally eaten away (Fig. 1 center and right).

This same erosion was exhibited on the solid silver wire (Fig. 2).

Scanning electron micrographs revealed only minimal changes in the metallic structure of the Sundt-Kees reinforcing clip applied to the Drake aneurysm clip. In an overall view of the prongs of the Drake aneurysm clip from this combination (Fig. 3 left), minimal abrasion and some dried salts from the saline solution were

Fig. 2. Scanning electron micrographs of a solid silver wire that was in contact with a Drake aneurysm clip in a saline bath. Left: Overall view of the silver wire. × 20. Right: View of the area of contact with the clip. × 80.
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FIG. 3. Scanning electron micrographs of a Drake aneurysm clip that was in contact with a Sundt-Kees reinforcing clip in a saline bath. The surfaces show minor abrasion and dried salts from the saline solution. Left: Overall view of the two prongs. Arrows show the area in contact with the Sundt-Kees clip. x 8. Center: View of the right prong at the contact area. x 64. Right: View of the left prong at the contact area. x 64.

seen at the area that was in contact with the Sundt-Kees reinforcing clip. The right and left prongs at the site of contact are shown in Fig. 3 center and right. Scanning electron micrographs of the Sundt-Kees reinforcing aneurysm clip also showed minor imperfections at the contact area of the “cups” (Fig. 4). This may be due to the weld formation and dried salts.

Phase II: In Vivo Studies

Color photographs of the clips that were implanted in the rats did not reveal anything other than the growth of fibrous tissue or a minimum of foreign-body reaction around it, which is generally consistent with implants.5,6 Scanning electron micrographs of the Sundt-Kees reinforcing clip showed no apparent corrosion within the “shoe” at the site of contact with the Drake clip (Fig. 5 left). The Drake aneurysm clip also showed no apparent change (Fig. 5 right).

Discussion

It is apparent from this study that the Sundt-Kees reinforcing aneurysm clip can be used in piggyback fashion over a Drake aneurysm clip without irritating the tissue or causing development of metallic toxicity by corrosion. Scanning electron micrographs of these
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clips showed little or no microscopic corrosion. The clips are made of similar (301) stainless steel, so the electrical energy of ionization of these two clips would be minimal since they should not have any potential difference between them. The difference in potential between the control Drake clip and the silver wire that it was attached to was more than enough to produce a significant amount of corrosion (approximately 200 mV or less) because they were made of dissimilar metals (301 stainless steel versus silver).

Previous studies by other investigators, including McFadden,6,7 Dujovny, et al.,3 Dymond, et al.,4 and DeLong and Ray,1 have shown that the “300” grades of stainless steel, which are austenitic, have generally good corrosion resistance. Mayfield and Kees5 implanted clips made of 301 stainless steel in the soft tissues of patients with malignant disease. At autopsy, there was no evidence of corrosion of the clip; however, there was a slight evidence of a foreign-body reaction.

Venable, et al.,10 showed in histology studies that the degree of damage to tissue by metal implants was approximately proportional to the galvanic activity. Thus, in our study using similar metals, the galvanic activity would be minimal. Aneurysm clips made of other metals should not be used with the Sundt-Kees reinforcing clip because of this obvious effect.

It must be noted that this short-term experiment of 6 months does not reveal the type of reaction that might occur in human tissue over a period of several years or even decades. The intention is only to show whether there is any metallic toxicity within the tissue. It is not the purpose of this paper to go into detail as to the mechanism of corrosion and its effects on tissue; however, the reader can be referred to an excellent review of this aspect by Sutow and Pollock.9

It is of paramount importance to understand that these clips are “passivated;” that is, these clips have a surface film of chromium oxide that protects them from corrosion. Therefore, these clips should be handled in such a manner as to avoid scratches or misbends which conceivably could promote corrosion.

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