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Effect of cable cerclage on regional blood circulation in rabbits: a scintigraphic study

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ABSTRACT

Purpose. To evaluate changes in blood circulation of the femoral cortex in rabbits using scintigraphy before and after cable cerclage alone or combined with an intramedullary Kirschner wire.
Method. Ten New Zealand rabbits were used. For the right femur, a 2-mm-thick cable was placed around the mid-diaphyseal region and squeezed with a 400-N force and locked with a clip. For the left femur, a 1.8-mm Kirschner wire was inserted retrogradely into the medullary canal, and a 2-mm-thick cable was applied using the same technique. The blood perfusion ratio of the region of interest (ROI) before and after surgery was evaluated using scintigraphy.
Results. For the right femurs, the mean ROI perfusion ratio decreased by 45% from 2.51 to 1.37 after intervention ($p=0.001$). For the left femurs, the mean ROI perfusion ratio decreased by 56% from 2.12 to 0.92 after intervention ($p<0.001$). The mean ROI perfusion ratio post-intervention was higher in the right than left femurs ($p=0.017$).
Conclusion. Cable cerclage around the femoral cortex significantly decreased blood circulation in the area.

Key words: *blood circulation; bone wires; femur; radionuclide imaging*

INTRODUCTION

Cable cerclage is used for fixation after osteotomies, for periprosthetic fractures, and for comminuted fractures. An intact blood supply to the bone is critical for fracture healing.[1] The blood is supplied by the periosteum and endosteum. After nutritional arteries enter the cortical bone, the longitudinal Haversian canals bring blood to the osteocytes. The perpendicular Volkmann canals enable communication between the Haversian canals and help distribute the arteries within the cortical bone.[2] In cadavers, the main arteries supplying bone are not affected by cable cerclage,[3] and bone microcirculation is not affected by cable fixation.[4] Nonetheless, the dynamic effects of cable cerclage on the blood supply are not well known. This study evaluated changes in blood circulation of the femoral cortex in rabbits using scintigraphy before and after cable cerclage

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alone or combined with an intramedullary Kirschner wire (Fig. 1).

MATERIALS and METHODS

This study was approved by the animal studies ethics board of our institution and conducted between [month year] and [month year]. Ten 8-month-old male New Zealand rabbits weighing 2500 to 3500 g were used. Intramuscular cefazolin sodium (20 mg/kg) prophylaxis was given. After anaesthesia with intramuscular 10 mg/kg ketamine and 8 mg/kg xylazine, the surgical site was disinfected with povidone-iodine solution. For the right femur, a 1-cm lateral longitudinal incision was made, and a 2-mm-thick cable was placed around the mid-diaphyseal region and squeezed with a 400-N force and locked with a clip (Fig. 2). For the left femur, a 1.8-mm Kirschner wire was inserted retrogradely into the medullary canal under fluoroscopic control, and a 2-mm-thick cable was applied using the same technique.

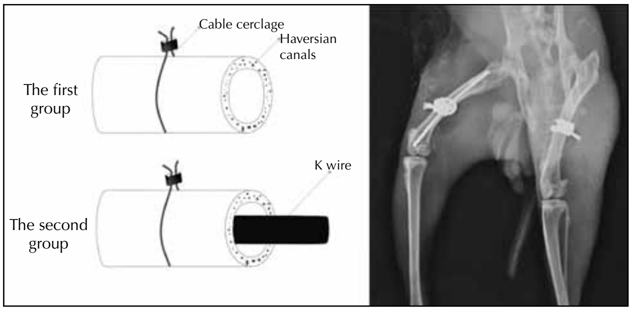

Figure 1 The right femur is fixed with cable cerclage alone, and the left femur is fixed with cable cerclage and intramedullary Kirschner wire.

Early- (first pass and blood pool) and late-phase (after 1 hour) scintigraphy was used to evaluate arterial blood supply and osteoblastic activity, respectively (Fig. 3). 1 mCi/kg technetium-99m-labelled methylene diphosphonate was administered intravenously 24 hours before and after the surgery. A large field-of-view gamma camera (Siemens Symbia E Dual- Head Gamma Camera, USA) equipped with a low-energy general-purpose collimator was used. Dynamic and static imaging used 64x64 and 256x256 matrices, respectively. The region of interest (ROI) was a 2x1 cm rectangle with the cerclage in the centre (Fig. 3). The ROI perfusion ratio was calculated using the total ROI value as the background. The average ROI count of the femoral shaft was calculated after subtracting the intact femoral soft-tissue activity to obtain late-phase parameters revealing osteoblastic activity, in turn indicating the level of blood supply. The same calculation was run pre- and post-intervention.

The paired samples *t*-test was used for comparison of the ROI perfusion ratio before and after intervention, and independent *t*-test was used for comparison of ROI perfusion ratio between groups. A p value of <0.05 was considered statistically significant.

Figure 2 A 2-mm-thick cable is placed around the mid-diaphyseal region and squeezed with a 400-N force and locked with a clip.

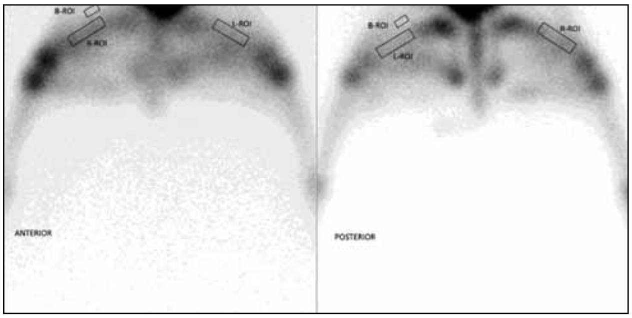

Figure 3 Scintigraphy before and after intervention is used for evaluation of arterial blood supply and osteoblastic activity. The region of interest is a 2x1 cm rectangle with the cerclage in the centre.

RESULTS

For the right femurs with cerclage alone, the mean ROI perfusion ratio decreased by 45% from 2.51±0.12 to 1.37±0.16 after intervention (p=0.001). For the left femurs with both cerclage and Kirschner wire, the mean ROI perfusion ratio decreased by 56% from 2.12±0.14 to 0.92±0.10 after intervention (p<0.001). The mean ROI perfusion ratio post-intervention was higher in the right than left femurs (p=0.017).

DISCUSSION

The use of cable cerclage remains controversial; it has been reported to have no negative effects on fracture healing,[3] but it has caused fracture nonunion in our clinical practice and in an animal study.[5] A special device has been used to protect the nutrient arteries around the femur and enable percutaneous cable cerclage, but no microcirculation data were reported.[6] In a dog study using microangiographic methods, cable cerclage did not disrupt the femoral cortical microcirculation, but microcirculation was evaluated after the cerclage wire was released.[4] The Haversian system may have protected the vascular structures within the bone, and reperfusion of bone may have occurred after the wire was released.[4] Transient cable fixation has no negative effect on fracture healing.[7] Nonetheless, most studies of bone circulation have examined non-living or static bone. In our study, changes in blood circulation of living bone before and after cable cerclage were evaluated. Although cable cerclage decreased blood circulation within the Haversian system, retrograde perfusion from the metaphyseal area was feasible. The blood circulation continued, albeit decreased, because of bone elasticity and resistance. The Kirschner wire was inserted without reaming the medullary canal and the endosteum was intact. The greater decrease in blood circulation was attributable to internal and external pressure on the microcirculation.

One limitation of our study was that the rabbit femur is smaller than the human femur. Nonetheless, the pressure applied to an area does not differ according to the size of the bone or cable. The resistance of the rabbit femur was not known. The perfusion rate was higher in the right femurs, possibly owing to right-side dominance. The right and left femurs should have been compared. A fracture model was not used because fracture haematoma may affect the results of scintigraphy. The surgery might have affected the blood supply. The femur has multiple arterial blood supply in different segments; blood supply to distal and proximal areas may continue.

CONCLUSION

Cable cerclage around the femoral cortex significantly decreased blood circulation in the area.

DISCLOSURE

No conflicts of interest were declared by the authors.

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