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Retardation of fracture healing by cerclage wire near the elbow in radius fracture models

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ABSTRACT

Cerclage wire is widely used in the treatment of fracture internal fixation and is shown effective in clinic. But a report by S.L. has pointed that the wire loop delayed the growth of bone. We have established a radius fracture model to study the possible detrimental effects of cerclage wire on fracture healing and the potential mechanism. By high-resolution CT analysis cerclage wire is found to delay fracture healing, by histological assessment cerclage wire is found to extended the time of hematoma and the marrow cavity appearing, by confocal microscopy cerclage wire decreased the content of calcium and the expression of alkaline phosphatase (ALP), and by RT-PCR analysis cerclage wire decreased the mRNA levels of bone sialoprotein and ALP. These results suggest that the cerclage wire near the elbow delayed the fracture healing in radius fracture models.

1. Introduction

Bone fracture is a common disease in clinic. Currently, there are profound theory and rich experience for the treatment of fractures. Cerclage wire is an important auxiliary means for fracture internal fixation, with the merits of firm fixation and easy to operate, and until now is widely used (Schroder et al., 2013; Larangeira et al., 2015; Berggren and Tiderius, 2014; Dickson et al., 2014; Gunadham et al., 2014; Kim et al., 2014).

The fixation effect of cerclage wire is to produce enough pressure on bone fragments. Cerclage wire used with locking plate fixation successfully treats periprosthetic fractures of the femur with faster time to union, less complication, and fewer revision (Ebraheim et al., 2013). Cerclage can be a useful method for initial reduction of displaced medial plates in acetabular fractures (Park et al., 2013). The combination of stainless steel wires and titanium plates does not compromise fracture healing or the postoperative clinical course (El-Zayat et al., 2013). Cerclage wiring is very useful and effective in the reduction and fixation of displaced associated anterior column and posterior hemi-transverse acetabular fractures (Lin et al., 2012). The use of a cerclage wire with a minimally invasive approach to aid and maintain reduction in certain subtrochanteric fracture patterns can be an effective surgical strategy to improve outcome (Tomas et al., 2013). Cerclage methods can be useful for initial reduction of displaced medial plates in acetabular fractures. These methods reduce operation time and blood loss as compared with other methods (Park et al., 2013). Cerclage wire repair results in higher stiffness than repair with an intramedullary pin (van der Zee, 2014). However, in some clinical cases, cerclage wire was found to have detrimental effects on fracture healing, which could induce hypertrophic nonunion and atrophic nonunion. For example, a report by BY S.L. et al. has pointed that the wire loop delayed the growth of bone (BY and Haas, 1945). In his exposition, one of the series of stimulation experiments showed that there was a loss of growth in the limb with the wire loop. And, a wire encircling the epiphyseal cartilaginous plate in the frontal plane will stop length growth from that plate (McKenna et al., 2013).

The aim of the present study is to investigate the effects of cerclage wire on fracture healing in a radius fracture model and study the potential mechanism. The study will provide a theoretical basis for the clinical detrimental effect of cerclage wire.

2. Materials and methods

2.1. Ethics statement

All experiments were executed in accordance with the Guide for the Care and Use of Laboratory Animals (National Institutes of Health Publication No. 80–23, revised 1996) and were approved by the Research and Ethics Committee of Jilin University.

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Table 1
Primers used for quantitative real-time PCR.

Target gene (*Rattus norvegicus*)	GenBank accession no.	Primer	Sequence (5′–3′)	PCR fragment length (bp)
Alkaline phosphatase	NM 013059.1	Forward	GCACCGCCACCGCCTACTTGT	161
		Reverse	GGTCACGATGCCCACGGATTT	
Bone sialoprotein	NM 012587.2	Forward	TCCTCCTCTGAAACGGTTTCC	73
		Reverse	CGAACTATCGCCATCTCCATT	
β-Actin	NM 031144.3	Forward	TGTCACCAACTGGGACGATA	280
		Reverse	ACCCTCATAGATGGGCACAG	

2.2. Materials

2.2.1. Animals and surgical procedures

Fifty-four rabbits (all females) which were 2–3 months and weighing 1.5 ± 0.1 kg and thirty-six rats (all females) which were 12 week and weighing 200–250 g were used in this study. The rabbits were randomly divided into three groups, each group including 18 rabbits. Rats were randomly divided into three groups, each group including 12 rats. These animals provided by the Center of Experimental Animals of Baiqiuen Medical College, Jilin University, China. The animals were randomly divided into three groups. Group A was sham-operated group, Group B and Group C were cerclage wire treatment groups.

The surgery was performed under strictly aseptic conditions. All operations are performed by a skilled person in the experiment to ensure that all cerclage wire was fastened to uniform tightness. After preanesthesia with propofol (5 mg/kg) and breathing anesthesia with isoflurane, the bilateral radius in the forelimb was exposed through a lateral longitudinal incision. The muscle was separated bluntly and the entire radial diaphysis was exposed. The radius and ulna were isolated by the steel plate. The periosteum was stripped off using a periosteal

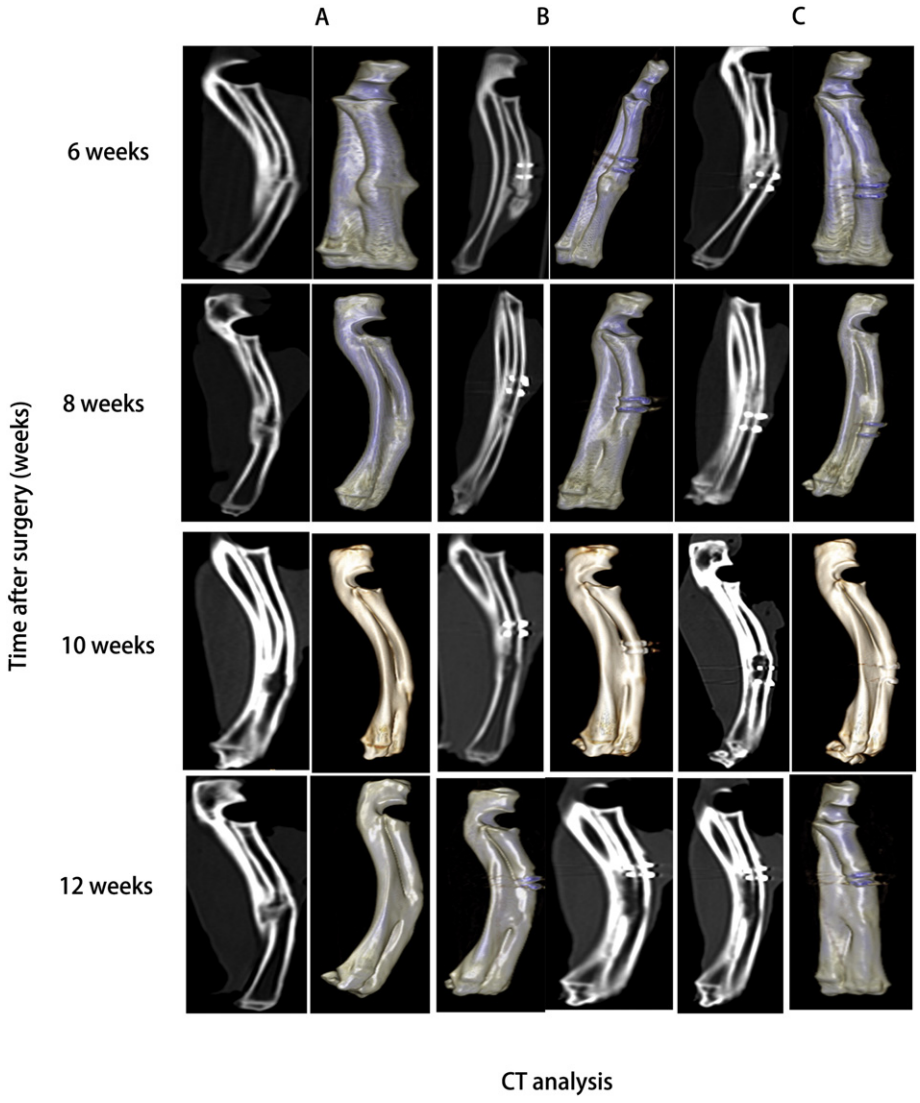

Fig. 1. Effects of cerclage wire on fracture healing by High-resolution CT analysis. A is sham-operated group; B cerclage wires is wrapped near the elbow and C cerclage wire is wrapped near the carpus. In the fig, a arrows are pointing the gap and b arrows are cerclage wire.