行政院國家科學委員會補助專題研究計畫成果報告

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※ 以骨節間鋼絲固定法來增進鎖定內釘 ※
※ 對肱骨未癒骨折之治療 ※
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計畫編號：NSC 89－2314－B－002－503

執行期間：89 年 08 月 01 日至 90 年 07 月 31 日

計畫主持人：林晉 台大醫學院骨科

本成果報告包括以下應繳交之附件：

□赴國外出差或研習心得報告一份

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□出席國際學術會議心得報告及發表之論文各一份

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行政院國家科學委員會專題研究計畫成果報告

Preparation of NSC Project Reports

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一、中文摘要

鎖定內釘在治療骨折會有起始不穩定的問題。本研究在比較鎖定內釘再加上馬蹄釘或骨段間鋼絲的方法時的機械性質。十八個人工肱骨分成三組：1）鎖定內釘；2）鎖定內釘加馬蹄釘；3）鎖定內釘加骨段間鋼絲。每組各六支肱骨，所有肱骨在中段橫切再以回朔式內釘方法固定，所有肱骨均以非破壞性之三點式彎折以及旋轉方式測試。以骨段間鋼絲固定組及以馬蹄釘固定組之起始不穩定度均統計上有定義的比較單純鎖定內釘高。但三者三彎折剛度及旋轉剛度並沒有意義之不同，問段間鋼絲固定組可提高較多之壓迫並減少骨折間隙。骨段間鋼絲固定可以有效地減少骨折間隙及不穩定度包括材料應用值得一試。

關鍵詞：鎖定內釘、馬蹄釘、骨段間鋼絲

Abstract

Locked nailing for humeral nonunions is threatened by the problems of residual fracture gap and fracture motion. A biomechanical study was conducted to investigate the effects of adding a staple or interfragmentary wiring to solve these problems. Eighteen artificial humeri were equally divided into three groups to compare the mechanical properties of three fixation methods: locked nail alone, locked nail with staple, and locked nail with interfragmentary wire. All of the humeri were transected and fixed by retrograde nailing. Nail-humeral constructs were examined by a nondestructive three-point bending test and a destructive torsional test. Fixation with a staple or interfragmentary wire had significantly less initial instability than did fixation with the locked nail alone both in the bending test and the torsional test ($p<0.01$), but no statistically significant difference of bending stiffness, torsional stiffness, or torsional strength was detected among the three groups. Interfragmentary wiring, however, provided tighter compression across the fracture site to close the fracture gap and better interdigitated the fragments. Interfragmentary wiring could effectively decrease the residual fracture gap and fracture motion simultaneously in fixation of transversely resected humeri with locked nails. Further clinical investigation is warranted.

Keywords: Locked nail, staple, interfragmentary wire

二、緣由與目的

Several biomechanical studies have described the initial instability of humeral locked nails caused by a nail's screw holes that are too large relative to the size of the screws, and some investigators have inferred that such instability was detrimental to fracture healing. This detrimental effect may be even greater in humeral nonunions, which may have a lower healing potential than do acute fractures. It has been reported that the residual fracture motion and fracture gap caused by initial instability was responsible for persistent nonunion in treatment of humeral nonunions by locked nailing. Two reports found that exchange nailing of humeral nonunions resulting from failure of intramedullary nailing tended to be complicated with high failure rates. The present authors thought that this distraction force might aggravate the negative effects of initial instability of humeral locked nailing.

The present authors hypothesized that adding a staple or interfragmentary wire might solve the problems of residual fracture gap and fracture motion. Staples have been effectively used across the fracture to increase the fixation stability in Seidel nailing of humeral nonunions, but that clinical experience was reported without the support of a biomechanical study of the real effects of the staple.

三、結果與討論

In this study, the extent of this initial instability was assessed by the translational displacement of the actuator at the load of 20 N in bending tests and the angular displacement of the actuator at the torque of 2 Nm in torsional tests. As determined by Bonferroni t-test, the initial instability of Group I was significantly higher than that of either Group II or Group III in both bending and torsional tests. This initial instability did not differ significantly between Group II and Group III. As for posteroanterior bending stiffness and mediolateral bending stiffness, torsional stiffness and torsional strength did not differ significantly among the three groups. All of the failures occurred at either the proximal or the distal screw holes of the nails. In Group II, the staples were twisted, on average, 27.4° . In Group III, the wires were loosened. No failure of the artificial humeri was observed. It was observed that the rigidity provided by the staple was affected by the purchase of the staple on the bone. The staple might slip out during torsional testing if it was not inserted deep enough. Although the staple might prevent gross angular or rotational motion, the authors found that it could not generate sufficient compression force across the fracture site to close the fracture gap. In fact, if not properly applied, the staple might even increase the fracture gap. In contrast to the staple, the interfragmentary wire generated substantial compression force, enough to eliminate fracture motion and gap between the fracture fragments. Intramedullary nailing has the advantages of less soft tissue trauma, lower risk of infection, and suitability for osteoporotic bone, but unlocked nailing with rotational instability has been complicated by high failure rate. This initial instability caused by the nail-screw interface has never been reported in locked nailing of the lower extremity, but it is repeatedly demonstrated in different kinds of humeral locked nails. In Russell-Taylor nails, the uncontrolled motion ranged from 4° up to 30°. At the torsional load of 2 N-m, the average rotational angle was 34.9° for Russell-Taylor nails, 10.6° for Synthes unreamed humeral nails, and 9.5° for the humeral locked nails in this study. For treatment of nonunions that result from failure of intramedullary nailing, exchange nailing produces high success rates in tibiae, but high failure rates in humeri. In tibiae, the initial instability may be stabilized by axial contact of the nonunion fragments during weight bearing and thus facilitate nonunion healing. In the current biomechanical tests, obvious fracture gap and fracture motion in axial, bending, and rotational directions were clearly discernible in the Group I humeri fixed with locked nails alone, even though double static locking was applied. For humeral nonunions resulting from intramedullary nailing, a wide medullary canal caused by osteolysis around the loosened nails was not uncommon. In fact, the fracture gap might even be increased if the pre-drill holes were too closely placed. Overall, the bending stiffness, torsional stiffness, and torsional strength of Group I and Group II nail-humeral constructs were not significantly different from those of Group III, but this result might be caused by a small sample size. Actually, the contact surface between two nonunion fragments might substantially affect the fixation stiffness and strength. The simple transverse osteotomy used in this study represented the worst scenario. Although how stiff and strong the ideal implants should be is still unknown, increasing compression on the bone could facilitate fracture healing and prevent implants from mechanical failure. In the biomechanical study using fresh cadaveric humeri, to eliminate the effects of fragment contact nail-humeral constructs were tested with 1-cm fracture gap. Because

of the initial gross motion of nail-humeral constructs, the testing results of this study were obviously not affected by fragment contact and could be compared with that of the study using fresh cadaveric humeri. The failure patterns of nail-humeral constructs in the present study using cortical transparent humeri, consistently occurring at the screw holes of the nail, were similar to those in the study using fresh cadaveric humeri. Results of the bending stiffness and torsional stiffness tests of the nail-humeri constructs were also similar, but the values were somewhat smaller in this study because of the relatively lower tensile modulus of urethane elastomer. Interfragmentary wiring is potentially associated with disadvantages. Soft tissue stripping for application of interfragmentary wiring and the wiring itself might impair the local circulation of the bone. The wire might cut out of the cortex during wire twisting in osteoporotic bones. Shortening of the humerus caused by tight interfragmentary compression might occur. A biomechanical study showed that the nail-humeral construct with interfragmentary compression demonstrated higher bending and torsional stiffness than that without interfragmentary compression. Unfortunately, its use for exchange nailing of humeral nonunions still resulted in a high failure rate. The present authors think that this kind of compression might be relatively limited by the position of the screw in the nail's screw hole. In another clinical report of three cases, adding a dynamic compression plate with the screws passing on either side of the nail countered the rotational instability of locked nails. To conclude, interfragmentary wiring and stapling could effectively decrease the residual fracture motion in fixation of the transversely resected humeri by locked nailing. Interfragmentary wiring could further eliminate the fracture gap by tight compression over the fracture site. Its clinical application is warranted.

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