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Original Article

Minimally Invasive Fixation for Proximal Humeral Fracture: A Review on the use of T2 Proximal Humeral Nail
以T2近端肱骨髓內釘為近端肱骨骨折病人進行微創內固定手術的回顧性研究

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ABSTRACT

Objective and methodology: A retrospective review of the outcome of patients who had proximal humeral fracture treated with T2 Proximal Humeral Nail from January 2007 to March 2011 was conducted. The demographics, union rate, and complications were reviewed. The patient outcome was assessed with the American Shoulder and Elbow Surgeons (ASES) score and Constant-Murley score.
Results: Thirty-two cases of traumatic proximal humeral fractures were included. The average follow-up period was 14.7 months. All fractures healed with an average of 3.97 months. The average forward flexion and lateral abduction of shoulder was 132° and 123°, respectively. The postoperative average Constant-Murley score was 67 (48-80) and ASES score was 82.9 (73-100). There was one case of avascular necrosis of humeral head. Six cases of minor screw complications required removal of screws later. No wound infection or neurovascular injury was found.
Discussion and conclusion: With the proper surgical technique high union rate, good functional recovery, and low complication rate can be achieved by using T2 Proximal Humeral Nail in managing traumatic proximal humeral fracture.

中 文 摘 要

中文摘要 目標與方法 我們在2007年1月至2011年3 月進行了一個以T2近端肱骨髓內釘治療近端肱骨骨折病人的效果之回顧性研究。我們調查了患者的統計資料，骨折愈合率及併發症，利用Constant Murley評分（Constant-Murley Score), 美國肩肘外科醫師會標準肩評估量表(American Shoulder and Elbow Surgeons Score)] 來評定病人的手術成效。 結果 我們的調查了32位患者，平均隨訪時間為14.7個月。所有骨折平均愈合期為3.97個月。肩膊的平均活動幅度分別為前屈132度及外展123度。術後的 平均Constant Murley評分 （Constant-Murley Score)為67 (48-80) 及美國肩肘外科醫師會標準肩評估量表（American Shoulder and Elbow Surgeons Score）平均為82.9分（73-100)。有1位病人出現肱骨頭壞死，6位出現輕微螺釘併發症，其後需進行移除鎳絲釘。在所有病人中並沒有發現任何傷口感染或血管神經損傷。 討論及總結 只要以適當的外科技術，使用近端肱骨髓內釘作治療近端肱骨骨折，是可以達到高的骨折愈合率，理想的肩膊功能恢復及低併發症的效果。

Introduction

Proximal humeral fracture is a common injury, which accounts for 5% of all fractures and 45% of all humeral fractures.[1] Elderly patients and patients with osteoporotic bones are particularly vulnerable.[2] The management of these fractures is challenging, especially for those with displacement, comminution, and osteoporosis. Depending on the fracture patterns, these can be fixed with percutaneous pinning, extramedullary devices (e.g., tension band or plates), intramedullary devices, or hemiarthroplasty.[3–8] The most devastating complication of conventional plating is the failure of fracture fixation.[9–12] Numerous studies found that anatomical locking plates improved the fixation stability and the position of the fracture fragments, resulting in better shoulder function.[13,14] Despite the use of these anatomical locking plates, complications such as loss of fixation, wound

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complication, malunion, and avascular necrosis were not uncommon, especially for three-part or four-part fractures. Hemiarthroplasty was a common method in treating comminuted four-part fractures in the elderly. Despite giving a good pain relief, the function and range of motion of the shoulder after hemiarthroplasty were less favourable than those treated with plates or nails.[15,16]

Intramedullary nailing, either antegrade or retrograde, in treating the humeral fractures is not popularised owing to its associated complications such as cuff damage, impingement or iatrogenic fractures. The newly designed locking nail for the proximal humeral fracture is a fixed angle device providing multiple locking options, threaded proximal locking holes, and washers for the greater and lesser tuberosity fragments. It has been shown to be biomechanically stronger than the locking plate for unstable fractures.[2]

Methodology

Between January 2007 and March 2011, all patients having traumatic proximal humeral fractures treated with T2 Proximal Humeral Nail at our hospital were studied. The fracture pattern is classified according to the AO = *Arbeitsgemeinschaft für Osteosynthesefragen* classification (Table 1), which can reflect the complexity of the fracture pattern, including metaphyseal and diaphyseal extension.

The T2 proximal humeral nail (T2-PHN; Stryker Corporation, USA) was used for treating two-part to four-part proximal humeral fractures. It is a titanium nail with variable length (150 mm, 220-300 mm). The standard version is a solid nail, and the long version is a cannulated one. It is a tapered device with a proximal 6° lateral bend and has left and right versions. There are four divergent proximal threaded locking holes for holding fracture fragments. The standard version has two distal locking holes for static or dynamic locking options, whereas the long version has three distal locking holes. Different sizes of end caps are available for fine adjustment of the length of the nail and increasing stability by optimising the purchase of the nail in the entry hole.

All surgeries were performed by the specialists from our trauma service team, and all patients underwent a standardised rehabilitation program. Radiological assessment by means of radiographs (anteroposterior and scapular lateral view) was performed immediately after the surgery and on every clinic visit upon discharge. Bony union, implant position, and possible complications were also assessed. The functional outcome was assessed by using Constant-Murley score and American Shoulder and Elbow Surgeons (ASES) score. Active forward flexion and abduction range of motion were recorded by a single physiotherapist.

Results

Between January 2007 and March 2011, 32 patients with traumatic proximal humeral fractures were treated with T2-PHN (Stryker) in our hospital. Demographics and fracture pattern are summarised in Table 2.

All fractures achieved bony union radiologically in an average time of 3.97 months (range, 2-6 months). For functional outcome, the average range of shoulder motion of active forward flexion and active lateral abduction was 132° (range, 105°-150°) and 123° (range, 100°-165°), respectively. The mean Constant-Murley score was 67 (range, 48-80), and the mean ASES score was 82.9 (range, 73-100).

There was one delayed union, in which the fracture healed at 6th month. This patient had failed conservative treatment and an operation was performed 4 weeks after the injury. There was one case complicated with avascular necrosis of the humeral head. She was an 83-year-old lady with comminuted three-part fracture. Satisfactory pain control could be achieved in this patient with occasional oral analgesics. Six minor screw complications (screw impingement in five patients and back-out in one individual) were observed. All of them received screw removal under local anaesthesia and had otherwise uneventful healing. None of the patients suffered from wound infection, neurovascular injury, loss of fixation, implant failure, or nonunion.

Discussion

The use of intramedullary nailing in treating proximal humeral fracture is always challenging, especially for those three-part or four-part fractures. This study demonstrated satisfactory results with the use of T2-PHN (Stryker) for various types of proximal humeral fractures, resulting in good active range of motion, a mean Constant-Murley score of 67 and ASES score of 82.9. Our results were satisfactory and comparable to other studies in the literature.[17–20]

Füchtmeier et al[21] studied the use of intramedullary and extramedullary devices in managing proximal humeral fractures. The intramedullary devices were biomechanically superior compared to the plating systems. They were also shown to have higher stiffness value, higher torsion, and bending stabilities.[21]

Rotator cuff problems and nail impingement are major concerns in using intramedullary nail in humeral fractures. These are commonly caused by cuff injury during nail entry, insecure repair of cuff, and improper nail insertion technique. In our study, none of our patients developed additional symptoms of rotator cuff problems compared to the preoperative status. For all our patients, we adopted a deltoid-splitting approach with careful longitudinal splitting of the supraspinatus tendon along the direction of its fibres at the more proximal vascular zone rather than around the insertion site. The cuff was well protected during reaming procedures. All bony debris that might cause irritation was thoroughly washed out, and the cuff was securely repaired with Ethibond-O, Ethicon, Johnson and Johnson, USA. The entry site of the nail was located in the articular cartilage. This could ensure adequate reduction with correct alignment and improve the final stability after the fixation.[22] Impingement of the nail was prevented by correct measurement of the nail length under fluoroscopic guidance and correct placement of

Table 1
AO classification of proximal humeral fracture

11-A **Extra-articular unifocal fracture**
11-A1 tuberosity
11-A2 impacted metaphyseal
11-A3 nonimpacted metaphyseal
11-B **Extra-articular bifocal fracture**
11-B1 with metaphyseal impaction
11-B2 without metaphyseal impaction
11-B3 with glenohumeral dislocation
11-C **Articular fracture**
11-C1 with slight displacement
11-C2 impacted with marked displacement
11-C3 dislocated

Table 2
Patients' demographics

No. of patients	32
Sex (Male:Female)	7:25
Mean age	71.3 (18-89 y)
Mean follow-up period	14.7 mo (5-42 mo)
Fracture classification	Type A = 12 (exclude A1)
	Type B = 12
	Type C = 8

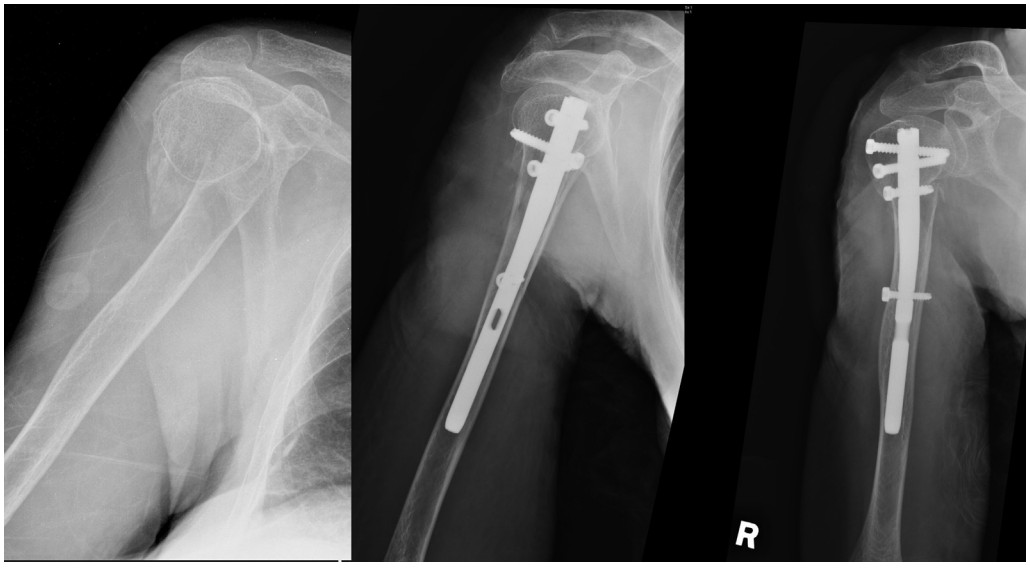

Figure 1. Two-part fracture of the proximal humerus in an 85-year-old lady. Postoperative X-ray showed satisfactory reduction and healing.

proximal end of nail 0.5 cm below the surface of the cartilage on the humeral head. (Figures 1 and 2)

In the literature,[18,19,23] backing out of screws was not uncommon. Mittlmeier et al[24] reported 59 cases of screw back-out in 115 patients treated with Targon humeral nail. The screws were removed under local anaesthesia, and the healing was uneventful. T2 PHN was designed to prevent these complications by the use of nylon bushings in the threaded proximal locking holes. This design improved the holding strength of the screws and prevented them from backing out. In our case series, there was only one case of screw back-out (Figure 3).

Managing three-part or four-part fractures of the proximal humerus by locked intramedullary nail is technically demanding and should be performed only by experienced surgeons. Van den Broek et al[25] demonstrated that most of the complications, such as screw migration, loss of tuberosity reduction, screw penetration into glenohumeral joint, and nail impingement, were related to technical errors, which could be avoidable. “Head-anchoring” technique is used in all our cases (Figure 4). Two Kirschner wire joysticks were driven into the humeral head fragment. The head fragment was then manipulated into alignment with the shaft of the humerus. With the head fragment stabilised, the proper entry site of the nail could be located in the articular cartilage, around 5 mm medial to the lateral edge of the cartilage. Impingement of the nail proximally could be avoided by proper seating of the nail below the subchondral bone. Penetration of articular cartilage by

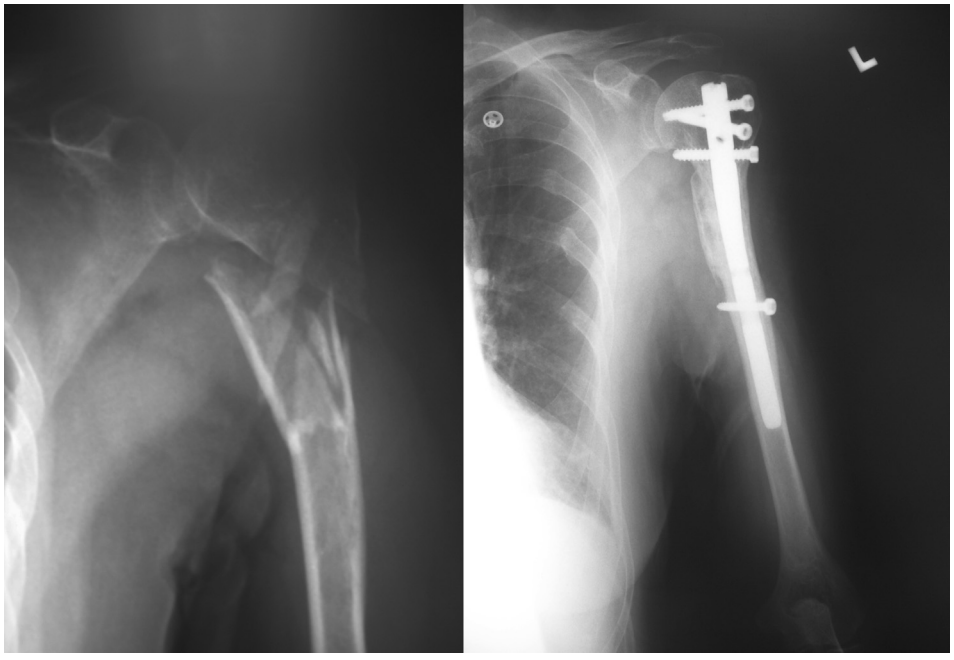

Figure 2. Seventy-seven-year-old lady suffering from comminuted three-part proximal humerus fracture with diaphyseal extension. The fracture completely healed after 1 year.

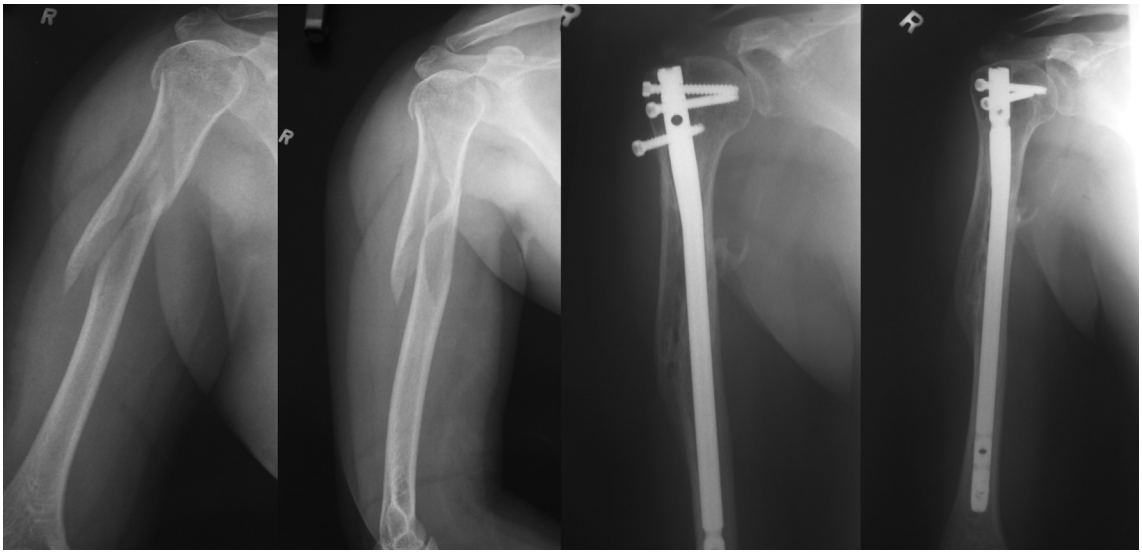

Figure 3. Fifty-seven-year-old lady with proximal humeral fracture with diaphyseal extension. The nail was later complicated with back-out of the most distal screw in the proximal locking holes which required removal after bony union.

proximal locking screws has also been reported by other authors.[26,27]

The low incidence of avascular necrosis of the humeral head was due to the preservation of the blood supply by the minimal invasive technique and the minimal disturbance of the fracture pattern by periosteal stripping and manipulation as in open reduction.[18–10,23,24]

Uncommon complications, such as wound or deep infection or axillary nerve injury, during insertion of proximal locking screws were reported in another study.[28] In our series, there was no infection, neurovascular injury, nonunion, loss of fixation, or implant failure.

There are limitations in this retrospective study including the small sample size. Further randomised controlled trials should be carried out to compare the other fixation devices for proximal humeral fractures.

In conclusion, by using proper refined surgical technique of T2-PHN for the management of proximal humeral fractures, one could achieve high union rate, good functional recovery, and low complications rate. Owing to the improved mechanical properties of the nail, it is a good choice for the treatment of these fractures, especially in the elderly with osteoporotic bone and with metaphyseal and diaphyseal extension.

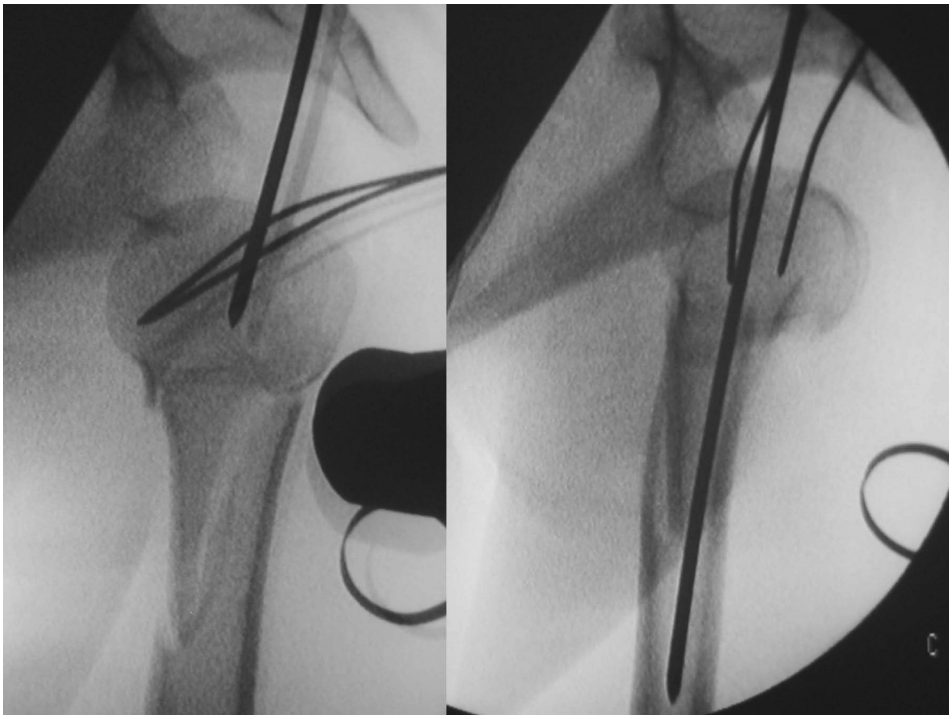

Figure 4. X-ray showing the use of Kirschner wires as joysticks for the reduction of fracture and stabilisation of the proximal fragment during the nailing procedure—"head anchoring technique".

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