

INTRAMEDULLARY PINNING WITH TENSION-BAND WIRING FOR SURGICAL NECK FRACTURES OF THE PROXIMAL HUMERUS IN ELDERLY PATIENTS

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Most proximal humeral fractures in the elderly population are related to osteoporosis. Several methods have been proposed to treat surgical neck fractures of the proximal humerus in elderly people. This study investigates a new method of intramedullary pinning with tension-band wiring. From June 1998 to March 2001, 10 female patients with a mean age of 73.0 years and displaced two- or three-part surgical neck fractures of the proximal humerus were studied. Two intramedullary pins were used with tension-band wiring via a deltopectoral approach with minimum dissection. The mean follow-up was 20.6 months. Final outcome was evaluated using the constant score, visual analog scale (VAS) score, questionnaire, and an outcome assessment form. The outcome was excellent in four patients, good in five, and fair in one. The mean Constant score was 80.8 and the VAS score was 83.0. There was no nonunion, avascular necrosis, deep infection, or pin migration. No patient needed further revision open reduction with internal fixation or prosthesis replacement. We therefore concluded that intramedullary pinning with tension-band wiring is a safe, reliable method, with few complications, for treating surgical neck fractures of the proximal humerus in elderly patients.

Key Words: surgical neck fractures of proximal humerus,
intramedullary pinning with tension-band wiring
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Proximal humeral fractures account for approximately 4–5% of all fractures [1]. The incidence of proximal humeral fractures increases exponentially after 50 years of age, with approximately 80% of such fractures occurring in women [2–4]. In the elderly population, most fractures of the proximal humerus are related to osteoporosis, and are often combined with thin and/or ruptured rotator cuffs. Consequently, they are predisposed to unsatisfactory clinical results [1,5,6].

According to Neer's classification [7], the proximal humerus is divided into four parts: the humeral head, the

greater tuberosity, the lesser tuberosity, and the shaft. By Neer's criteria, the displaced fragment is displaced 1 cm or angulated at 45° to any of the remaining three fragments. Two-part surgical neck fracture is the most common type of displaced proximal humeral fracture. In general, non-displaced two-part fractures have good prognosis after conservative treatment with sling protection and early range-of-motion exercises [8]. However, treatment of displaced two- or three-part surgical neck fractures of the proximal humerus remains a topic of debate and investigation. Several methods have been proposed to treat displaced surgical neck fractures of the proximal humerus, including conservative treatment with sling protection and early exercises [9,10], percutaneous pinning [11], fixation with plates and screws [12,13], multiple flexible nails [14], heavy sutures, cerclage wire alone [12,15] or in combination with a tension band [16,17], external fixators [18], Rush nails

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[15,19,20], and Enders nails [11]. The choice of technique depends on the fracture pattern, bone quality, the surgeon's experience, and the patient's reliability. The blood supply to the humeral head puts its viability at risk, not only from the injury, but also from operative dissection of the soft tissue for fracture reduction and implant insertion [12,21]. Extensive dissection and bulky implant insertions increase the risk of avascular necrosis (AVN) of the humeral head [12,22]. Therefore, limited exposure and dissection of the soft tissue at the fracture site and minimal internal fixation are recommended [12,13].

The Enders nail is designed to treat surgical neck fractures of the proximal humerus, improving fixation quality and maintaining humeral length. The superior holes of the Enders nail allow the passage of sutures for deeper placement of the rod in the rotator cuff, so that it is less prominent and prevents impingement against the acromion. In 1992, Cuomo et al reported a satisfactory result with these techniques in 18 of 22 patients (82%) [23]. We used the concept of Enders nails but replaced them with easily available materials such as pins and wires and two intramedullary pins with figure-of-eight tension-band wiring to treat surgical neck fractures of the proximal humerus in elderly patients.

PATIENTS AND METHODS

From June 1998 to March 2001, 20 patients with proximal humeral fractures underwent surgery by the senior author (GT Lin) in the Department of Orthopedic Surgery at the Kaohsiung Medical University Hospital. The inclusion criteria were that the patient was more than 60 years old and had a displaced two- or three-part surgical neck fracture of the proximal humerus but not a pathologic fracture, and no other fractures or deformities in the upper extremity. Twelve patients met these criteria but two were later lost to follow-up due to changes of address. Ten patients finished the final

follow-up and were included in the study. All 10 patients were female, with a mean age of 73.0 ± 7.6 years (range, 60–84 years). Mean follow-up duration was 20.6 months (range, 8–32 months). According to Neer's classification, eight patients had two-part surgical neck fractures, one had a three-part surgical neck and greater tuberosity fracture, and one had a nonunion surgical neck fracture. Seven patients had right injuries and three had left injuries. They all underwent double intramedullary pinning and tension-band wiring.

All 10 patients completed the Constant and Murley scoring system [24], clinical outcome assessment [6], and shoulder assessment questionnaire at the final follow-up. The Constant and Murley scoring system included the clinical criteria of pain (15 points), range of motion (40 points), power (25 points), and activities of daily living (20 points). The results of the clinical outcome assessment were graded as excellent, good, fair, and poor, according to factors that included the requirement for analgesics, limitation of recreational activities, limitation of daily activities, and patient's assessment (Table 1). The pain scores had a four-level scale: none (15 points), mild (10 points), moderate (5 points), or severe (0 points). Activities of daily living scores were assessed by the ability to work, engage in leisure or sports activities, and experience undisturbed sleep. The range-of-motion scores included active painless flexion, abduction, and external and internal rotation as measured using a goniometer. The shoulder assessment questionnaire included basic data, a visual analog scale (VAS; from 0, dissatisfied, to 100, very satisfied), radiography assessment, associated complications, and willingness to undergo the same procedure again.

Radiography assessment included anteroposterior and lateral views to assess union, nonunion, malunion, AVN, and osteoarthritis. Malunion was defined as healing of the fracture with an anteroposterior (AP) angulation of more than 20° and/or a mediolateral angulation of more than 40°

Table 1. Outcome criteria

Grade	Pain	Requirement for analgesics	Limitation of recreational activities	Limitation of daily activities	Patient's assessment
Excellent	None	None	None	None	Satisfied
Good	Mild, occasional	Occasionally	Limited	Limited	Satisfied
Fair	Moderate, frequent	> 1 dose per week	Moderate	Moderate	Satisfied with reservation
Poor	Severe, nearly always	Daily	Severe	Severe	Dissatisfied, or re-operate

Table 2. Details of 10 patients who underwent intramedullary pinning with figure-of-eight tension-band wiring for proximal humeral fractures

Case	Gender	Age (yr)	Fracture pattern	Injury side	Constant score	VAS	Grade	Complications	Remove implant
1	Female	78	Nonunion of surgical neck fracture	Right	89	95	Excellent	Pin penetration	Yes
2	Female	76	2-part surgical neck	Left	52	75	Fair	Subacromial crepitus	Yes
3	Female	64	2-part surgical neck	Right	85	80	Good	Mild shoulder soreness	No
4	Female	78	2-part surgical neck	Right	89	90	Excellent	None	No
5	Female	66	2-part surgical neck	Right	82	90	Excellent	None	No
6	Female	76	3-part surgical neck	Right	75	80	Good	None	No
7	Female	84	2-part surgical neck	Right	80	80	Good	None	No
8	Female	70	2-part surgical neck	Left	85	70	Good	None	Yes
9	Female	60	2-part surgical neck	Right	89	90	Excellent	None	No
10	Female	78	2-part surgical neck	Left	82	80	Good	None	No

VAS = visual analog scale.

[6]. Table 2 shows the patients' details.

Operative technique

The operation was performed under general anesthesia with the patient in a semi-sitting position. After carefully sterilizing the arm and shoulder, the deltopectoral approach was used to preserve the origin and insertion of the deltoid and axillary nerves. With careful minimum dissection of the soft tissue and fracture fragments necessary for adequate exposure, the interposed soft tissue was removed from between the fracture fragments. Fractures were reduced and fixed temporarily with reduction clamps under direct visualization. Two small longitudinal incisions on the rotator cuff were created to insert the K-wires. Two parallel 2.0 or 2.4 mm smooth K-wires were then inserted through the rotator cuff incisions into the humeral medullary canal, until the "end point" of the bottom of the humeral canal was felt (Figure 1A). A hole was drilled in the shaft of the humerus, approximately 1 inch below the fracture site, and an 18 or 20 gauge wire was passed through the hole. The wire was looped back in a figure-of-eight configuration and passed through the rotator cuff and the intramedullary K-wires. The wire was twisted tightly and incorporated into the rotator cuff and K-wires to reduce and stabilize the head fragment with a tension-band to the humeral shaft. The K-wires were retrograded several centimeters, and the wire tips were cut at acute angles and bent 180° in a reverse U shape (Figure 1A). The K-wire tips and tied wire tips were then embedded deeply into the greater tuberosity beneath the surface of the rotator cuff tendon, and the incisions on the rotator cuff were closed to prevent the K-wires migrat-

ing upwards. Finally, we checked reduction stability and repaired rotator cuff defects, if present, with non-absorbable sutures. The subcutaneous and skin layers were closed routinely (Figures 1B and 2). The arm was immobilized in a shoulder sling for 4–6 weeks. Pendulum exercises were started on the second and third days after pain had subsided. Passive elevation was encouraged at about 2 weeks while the wound healed and the shoulder was without pain. Active range-of-motion exercises were arranged when there was radiologic evidence of early bone healing at around 6–8 weeks. Postoperative serial radiographs were arranged at an outpatient clinic.

RESULTS

The average follow-up was 20.6 months with a minimum of 8 months. The mean Constant score was 80.80 ± 11.07 (maximum score, 100), the mean pain subscale was 13.00 ± 2.58 (maximum, 15), the mean activities of daily living subscale score was 17.00 ± 3.16 (maximum, 20), the range-of-motion subscale score was 34.2 ± 4.94 (maximum, 40), and the mean power subscale score was 16.60 ± 3.24 (maximum, 25). For the final outcome assessment, the mean VAS score was 83.00 ± 7.89 (maximum, 100). Nine patients had good to excellent results (4 excellent, 5 good) and one patient had a fair result; no patient was graded as poor.

The fracture union rate was 100%, as confirmed by radiologic evaluation. No patient developed deep infection, AVN, osteoarthritis, or malunion. One patient (Case 3) complained of mild shoulder soreness and weakness, and

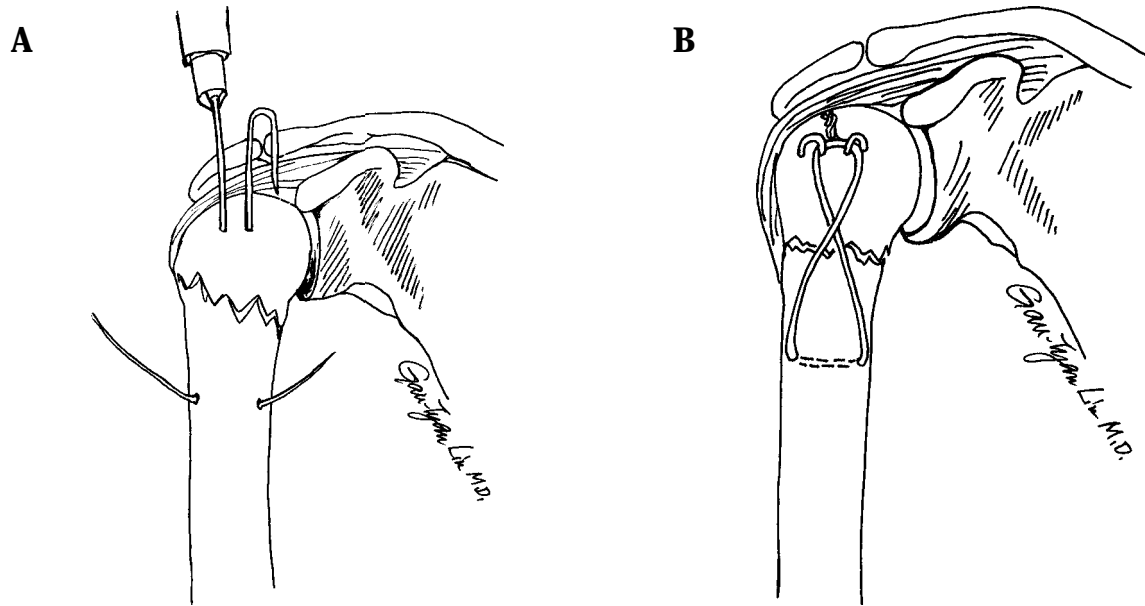


Figure 1. Intramedullary pinning with figure-of-eight tension-band wiring. (A) The surgical neck fracture is reduced under direct vision and the 2.0 or 2.4 mm K-wires are inserted through the rotator cuff beyond the greater tuberosity, until the “end point” of the bottom of the medullary canal is felt. A figure-of-eight tension band wire is passed underneath and incorporated in the rotator cuff and intramedullary pins to reduce and stabilize the head fragment to the humeral shaft. The K-wire tips are cut and bent into acute angles, forming a reverse U shape. (B) The K-wire tips are embedded in the humeral head and the stability of the reduction is checked and rotator cuff defects, if present, are repaired.

one patient (Case 2) complained of subacromial crepitus during range-of-motion exercises, but impingement tests were negative and no pin migration was found. During the

initial stages of this new surgical technique, one patient (Case 1) experienced K-wire penetration through the humeral shaft cortex, detected by postoperative radiography.

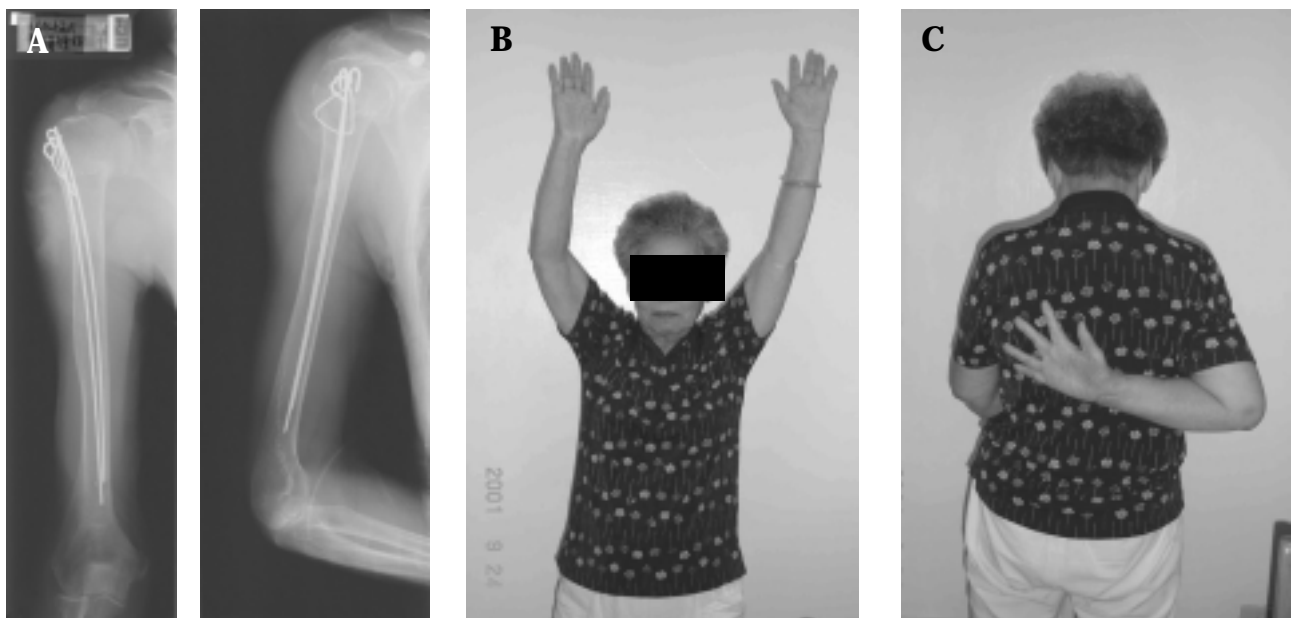


Figure 2. Case 4: a 78-year-old female sustained a two-part surgical neck fracture of her right proximal humerus and underwent intramedullary pinning with figure-of-eight tension-band wiring. (A) Postoperative roentgenograms. (B, C) Six months after surgery, the fracture had healed and 160° forward elevation and internal rotation to the interscapular space was achieved. The final outcome was excellent.

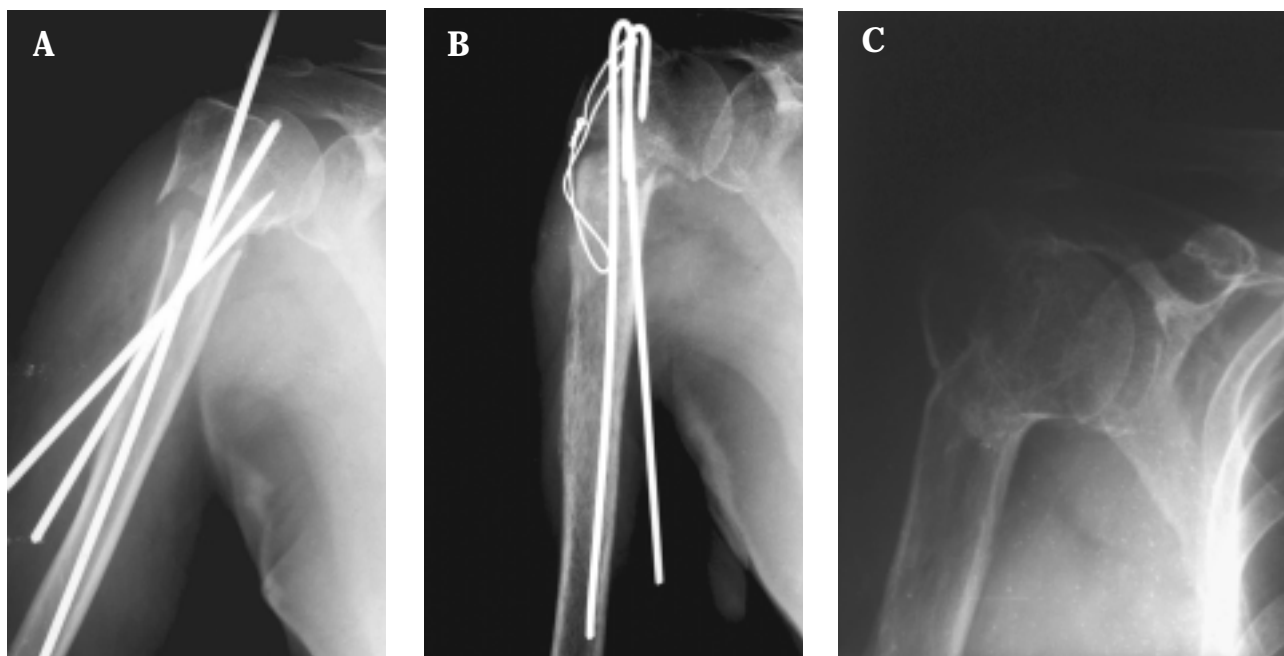


Figure 3. Case 1: a 78-year-old female patient suffered from a displaced three-part surgical neck fracture of the right proximal humerus after falling. She underwent percutaneous multiple pinning fixation at another hospital. (A) Postoperative roentgenograms after 6 months reveal loss of reduction and nonunion. She then underwent intramedullary pinning with figure-of-eight tension-band wiring. (B) Due to our limited experience with this method, the pin penetrated the shaft cortex. (C) The patient asked for the implant to be removed after the fracture had healed and she had an excellent outcome.

However, the fracture finally healed, no revision surgery was required, and this patient had an excellent outcome (Figure 3). No patients required revision surgery or prosthesis arthroplasty. Three patients asked to have the implant removed for pin penetration of the humeral cortex (Case 1), shoulder crepitus (Case 2), and other reason (Case 8).

DISCUSSION

Proximal humeral fractures are not uncommon among elderly people, as the surgical neck area is the weakest region of the proximal humerus. Many elderly people have osteoporosis or otherwise poor bone quality in this area, often combined with a thin or ruptured rotator cuff. Displaced two-part surgical neck fractures may require open reduction and internal fixation, either because of soft tissue interposition between the fracture fragments or failed close reduction [25]. Numerous techniques and devices have been proposed to treat surgical neck fractures of the proximal humerus, including conservative treatment with sling immobilization and early motion exercises [9,10], percutaneous pin fixation [11], plates and screws [12,13], Rush nails [15,19,20], Enders nails with wiring [11], external

fixators [18], heavy sutures, and cerclage wiring alone or in combination with tension-band techniques [16,17]. Limited exposure and dissection of the soft tissue at the fracture site, with minimal internal fixation, is recommended by Hintermann et al [6]. In addition, adequate stable fixation, early range-of-motion exercises, and an aggressive rehabilitation program are important in treating surgical neck fractures in elderly patients.

Clinically, several series on the percutaneous pinning technique reported results varying from excellent (70% of patients reported excellent results) [11] to poor (< 40% of patients reported excellent results) [12,25]. Percutaneous pinning has a high incidence of complications, including nonunion, pin tract infection, and pain during shoulder motion due to inadequate fragment stability and soft-tissue impingement [26]. Elderly patients with osteoporotic bone and inadequate bone purchase for percutaneous pinning are at risk of loss of reduction, pin loosening, and delayed rehabilitation. Younger patients with good bone quality can achieve stable fracture reduction by means of fixation with plates and screws for proximal humeral fractures. However, the plate-and-screws method may not be suitable for elderly patients with surgical neck fractures of the proximal humerus because of osteoporotic bone, resulting in inadequate and

unstable screw purchase in the proximal fragments [27]. In addition, extensive dissection of soft tissue and insertion of bulky implants increase the risk of AVN [12,22]. Standard T plates and screws require stripping of the periosteum and surrounding tissue, depleting osteogenic sources for healing and disrupting major vessels supplying the humeral head and shaft. One series reported AVN in 34% of patients who underwent plate fixation [13]. The heavy suture or figure-of-eight tension-band wiring technique is also useful, but Koval reported a loss of reduction with modified tension-band wiring in 27% of cases [28]. Intramedullary devices such as the Rush rod and Enders nail can improve fixation strength and maintain humeral length, and several authors have reported good results using the Rush rod for surgical neck fractures of the proximal humerus [19,20,29]. However, the Rush rod may not have adequate rotation control of the displaced surgical neck fragments and may impinge against the acromion, leading to implant removal [28].

Our method of intramedullary pinning with figure-of-eight tension-band wiring is modified from Enders nail fixation for proximal humeral fractures. We used the deltopectoral approach with careful dissection and preserved the soft tissue and periosteum to prevent AVN. During the operation, we reduced the fracture site under direct visualization to prevent malalignment. Due to limited experience during the earlier stage of this new surgical technique, the K-wires penetrated one patient's humeral shaft. We now use the "end point" method to confirm the intramedullary pin's position and prevent pin penetration. With this method, there was no further K-wire penetration, and intraoperative fluoroscopy was unnecessary. The wire tips were cut at acute angles and bent 180° in a reverse U shape, then pushed and embedded into the humeral head beneath the rotator cuff, to reduce the possibility of upward migration and acromion impingement. In many instances, the rotator cuff may have better tissue quality than the osteoporotic bone of the proximal humerus [28]. The figure-of-eight wire incorporated in the rotator cuff can improve proximal fixation and rotation stability by means of the tension-band effect. Intramedullary pinning with figure-of-eight wiring is a low-profile implant, but the device provides sufficient stability for elderly patients with osteoporotic bone and allows early motion. The rotator cuff can be repaired at the same time, if necessary.

In our series, this method produced good results when compared with other methods of treating proximal humeral fractures in elderly patients. Nine patients had good to excellent results, only one patient was graded as fair, and no patient was graded as poor. The Constant score was 80.80

and the VAS score was 83.00. Of the 10 patients, eight had two-part surgical neck fractures, one had a three-part surgical neck and greater tuberosity fracture, and one had a nonunion surgical neck fracture. Subsequent radiographic examination showed that all fractures had united. No deep infections, AVN, or upward pin migration were found. Only one patient complained of mild shoulder soreness and one patient sustained subacromial crepitus, but the impingement tests were negative. In addition, no patient required revision open reduction with internal fixation or prosthesis arthroplasty. Finally, the implant can be removed easily through a small incision without complications.

CONCLUSION

Intramedullary pinning with figure-of-eight wiring is an easy, safe, inexpensive, and reliable method. It results in fewer complications than other methods and is stable enough to treat proximal humerus fractures in the elderly. However, due to the limited number of cases in this study, further research and long-term follow-up are necessary.

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老年人之近端肱骨骨折以 髓內釘合併張力帶鋼絲治療之結果

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老年人之近端肱骨外科頸骨折大多數是因骨質疏鬆所引起的。針對這種類型的骨折已經有許多的治療方式被提出。這篇研究的目的是在於使用髓內鋼釘合併張力帶鋼絲固定之方式來治療老年人之近端肱骨外科頸骨折。從 1998 年六月到 2001 年三月，我們收集了 10 名有移位性之近端肱骨外科頸骨折的老年婦女，平均年齡為 73.0 歲，平均追蹤時間為 20.6 個月。其中 4 名病人其結果為優良，5 名病人為良好，1 名病人為普通。平均之 Constant 分數為 80.8 分，而 VAS 分數為 83.0 分。在本研究中，沒有病人發生骨折未癒合，缺血性壞死，感染或鋼釘移位，也沒有病人需要再度的實施開刀復位內固定或是人工關節置換。我們總結使用髓內鋼釘合併張力帶鋼絲之方式來治療老年人之近端肱骨外科頸骨折是一個安全，可靠，很少併發症的治療方式。

關鍵詞：近端肱骨外科頸骨折，髓內鋼釘合併張力帶鋼絲治療
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