Internal Fixation of the Clavicular Fracture : Biomechanical Aspects of Plating and Intramedullary Pinning with and with out Supplement of Intraosseous Wiring

Thossart Harnroongroj, M.D., and Vichai Vanadurongwan, M.D.
Department of orthopaedic surgery, Siriraj hospital, Faculty of medicine, Mahidol University, Bangkok, Thailand.

ABSTRACT

A study is carried out on the bending moment and rotational stability of the plating and intramedullary pinning with and without intraosseous wiring osteosynthesis for the clavicular fracture. The position of the clavicle in the experiment was set as in the shoulder girdle. A load was applied at its distal end until failure of the osteosynthesis by the universal testing machine. The results found that the plating osteosynthesis group could bare the bending moment of 12.05±1.74 Nm. and 12.65±0.92 Nm. for the group of intramedullary pinning osteosynthersis with 3.6 mm. Steimann pin. For the rotational stability, the group of plating osteosynthesis could bare the torsional mement of 4.82±0.65 Nm. and 4.65±0.48 Nm. for the group of intramedullary pinning osteosynthesis with 3.6 mm. Steimann pin and supplement with a 1.2 mm. intraosseous wire. The statistical analysis showed that no differences of the bending moment stability of plating and intramedullary pinning osteosynthesis, as well the torsional moment stability of the plating and intramedullary pinning supplement with an intraosseous wire osteosynthesis.

Clinical relevance

Whenever there is indication for open reduction and internal fixation of the clavicular fracture either plating or intramedullary pinning is recommended to achieve the good stability of the osteosynthesis but the intramedullary pinning should be supplemented with an intraosseous wire to achieve the rotational stability.

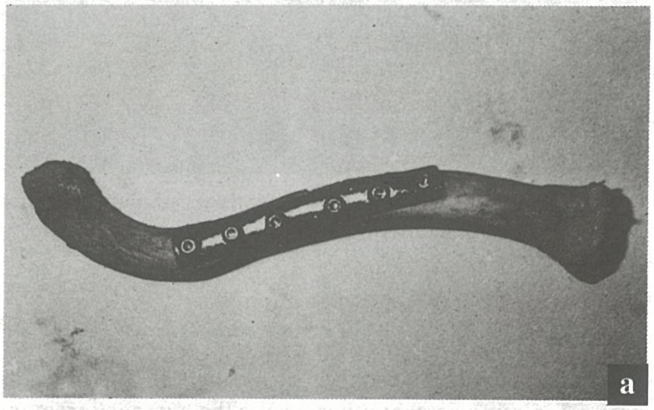
There are various types of implants for internal fixation of the clavicular fracture[3,5,6] including plates, intramedullary pins, Cerelage wires and external fixation. However clinically the most commonly used implants are either the plates or intramedullary pins[1,5]. Furthermore no comparative studies exist about the biomechanics of plating osteosynthesis versus intramedullary pinning for the clavicular fractures. Therefore the aim of this study was 1. to compare the bending moment stability between plating and intramedullary pinning osteosynthesis and 2. rotional stability between plating and intramedullary pinning supplemented with intraosseous wiring osteosynthesis for the clavicular fracture.

MATERIALS AND METHODS

Twenty clavicles were obtained from fresh cadavers without known metabolic bone diseases, malignant tumor or other significant pathologic conditions and in age range from 20-30 years. The entire soft tissue envelop of the clavicles was excised. A treansverse fracture at middle part of the clavicle was created by an osteotomy with a saw. Twenty clavicles were divided into 4 groups. Group 1 and 2 were tested for bending mement. Both groups 1 and 2 consisted of 6 clavicles with the same numbers of right and left sides. The group 1 were performed plating osteosynthesis with a 6 hole one-third tubular plate (synthes, Bettlach, Switzerland) by OA technique. The plate was placed on the superior aspect of the clavicles (Fig 1). The group 2 intramedullary pinning with 3.6 mm. Steimamm pin (Zimmer, Indiana, U.S.A). Group 3 and 4 were used for testing of rotational stability. Group 3 and 4 consisted of 4 clavicles with the same numbers of right and left sides. Group 3 was plated and group 4 had intramedullary pinning osteosynthesis as the group 1 and 2 respectively. But in group 4, intramedullary pinning was supplemented with one intraosseous wire (Fig 2). The technique of intraosseous wiring used a 1.2 mm. diameter stainless steel wire (Zimmer, Indiana, U.S.A) passed through the drilling hole which was 2 mm. from each fracture site and direction of the wire loop was across the intramedullary pin. The intraosseous wire was tightened with 40 lb tension by the wire tightener (Osteo AG, Selzach, Switzerland). All specimens were tested at room temperature. The clavicles in group 1 and 2 were set the position for testing as in the shoulder girle. The sternal end of the clavicle was put into the hole of stable base rectangular metal plate and the distal end of the clavicle was elevated 2 cm. above the sternal end. The position of the clavicle was fixed by appling acrylic cement between the sternal end and the hole of the rectangular metal plate. A wedge shape metal was put under the clavicle between the osteotomy site and the sternal end, adjusted its height just contacted with inferior cortex of the clavicle, 1 cm. from the osteotomy site. By using the universal testing machine Shimadzu AG 2000 (Shimazu, Kyoto, Japan) the compression load at a rate of 5 mm. per minute was applied at the distal clavicle, 4 cm. from the osteotomy until the osteosynthesis failed (Fig 3). For the group 3 and 4, the specimens were tested for torsional moment by the same universal testing machine, with distance between the upper grip and the lower grip was 10.5 cm. and speed of testing 3 mm. per minute until the displacement between the fragments of osteosynthesis was 35 degree (Fig 4). The maximal load was recorded by the monitor of the machine. The statistical analysis performed by Studentís paired t-test.

RESULTS

In group 1, the plating osteosynthesis gave the average maximal load of 301.20±43.50 N. and the average maximal bending moment of 12.05±1.74 Nm. (Table 1). The failure of osteosynthesis had bending of the plate and fracture of the inferior cortex of the clavicle (Fig 5). In group 2, the intramedullary pinning osteosynthesis gave the average maximal load of 314.8±22.10 N. and the average maximal bending mement of 12.65±0.92 Nm. (Table 1). The failure of soteosynthesis had distraction of



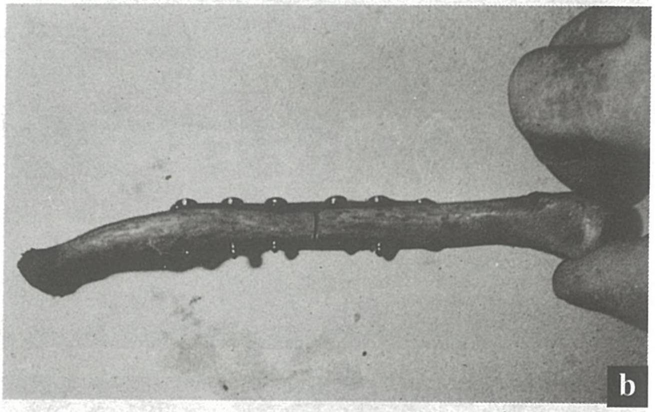
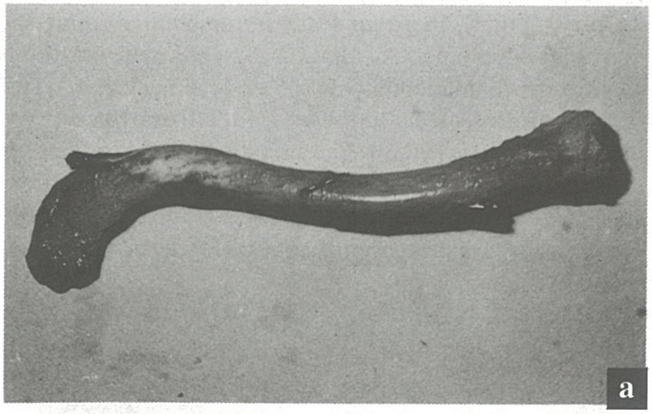


Fig. 1 The superior plating osteosynthesis of the clavicular fracture with 6 hole one-third tubular plate and 3.5 mm. cortical screws, superior view (a) lateral view (b)



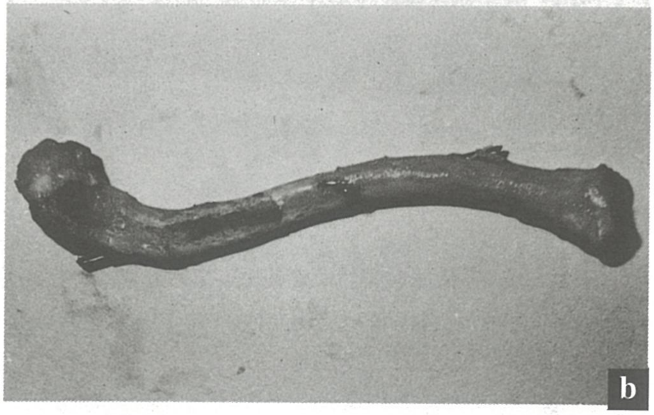


Fig. 2 The intramedullary pinning osteosynthesis of the clavicular fracture with 3.6 mm. diameter Steimann pin, supplemented with a 1.2 mm. diameter intraosseous wire, superior view (a), posterior view (b)

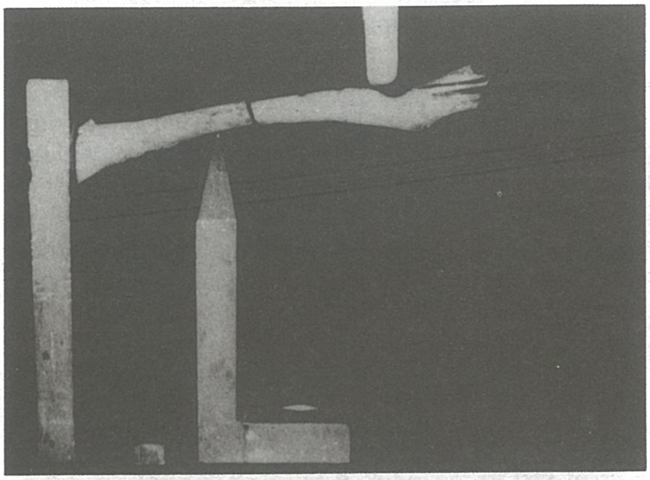


Fig. 3 The clavicle was adjusted to allow the tip 2 cm. above the sternal end. The sternal end was fixed in the hole of stable base rectangular metal by acrylic cement. The wedge shape metal was inserted beneath the clavicle between the osteotomy site and the sternal end, 1 cm. from the osteotomy. The height of the wedge metal was adjusted to contact the inferior cortex of the clavicle. The load was applied at distal end of the clavicle, 4 cm. from the osteotomy.

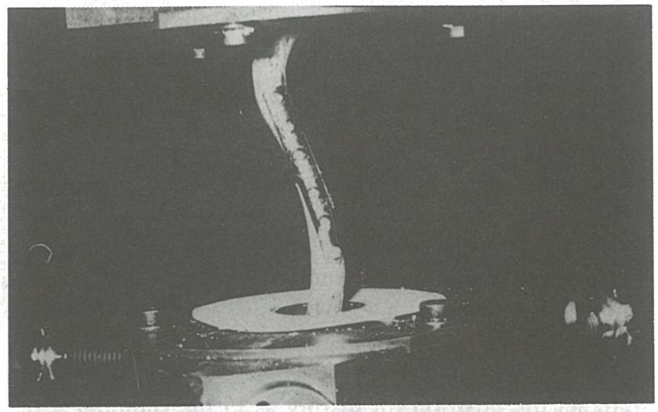


Fig. 4 The osteosynthesis of the clavicular fracture was tested under torsional load by universal testing machine.

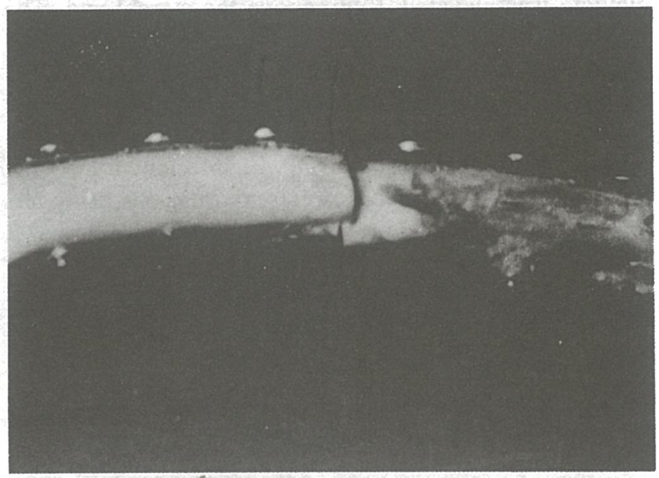


Fig. 5 The failure of plating osteosynthesis of the clavicular fracture showed fracture of inferior cortex at osteotomy site.

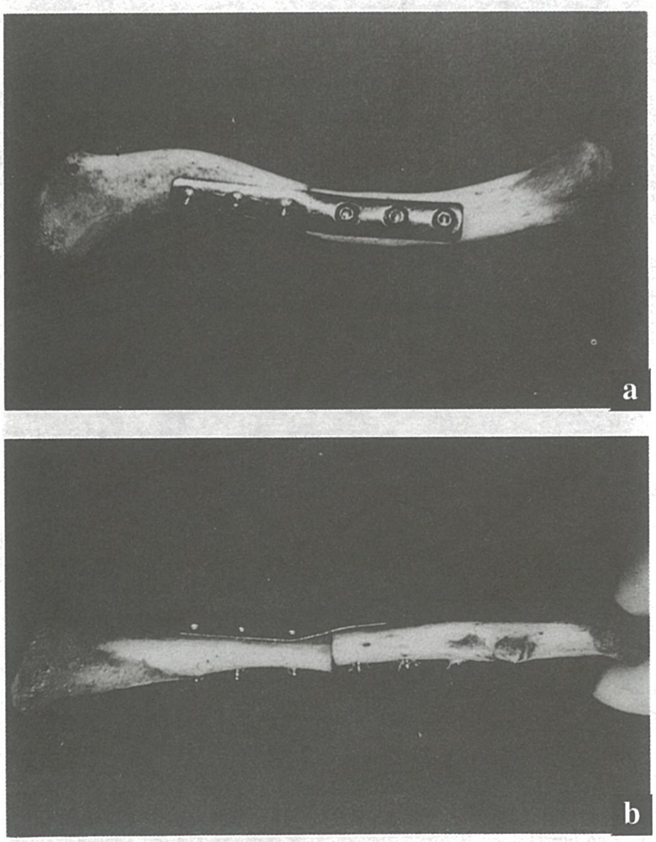


Fig. 6 Failure of the plating osteosynthesis with twist deformity of the plate at the fracture site.

the fracture site and rotation of the lateral fragment. In group 3, plating osteosynthesis gave the average torsional moment of 4.82±0.65 Nm. (Table 2) and failure point occurred at the osteotomy sites with twist deformation of the plate (Fig 6). In group 4, the intramedullary pin fixation with supplement of the intraosseous wire gave the average torsional moment of 4.65±0.48 Nm. (Table 2) and failure of the osteosynthesis had elongation of the intraosseous wire (Fig 7). The statistical analysis revealed that between the group 1 and 2 had no significant differences in bending moment stability as well between the group 3 and 4 had no significant differences in the torsional moment stability.

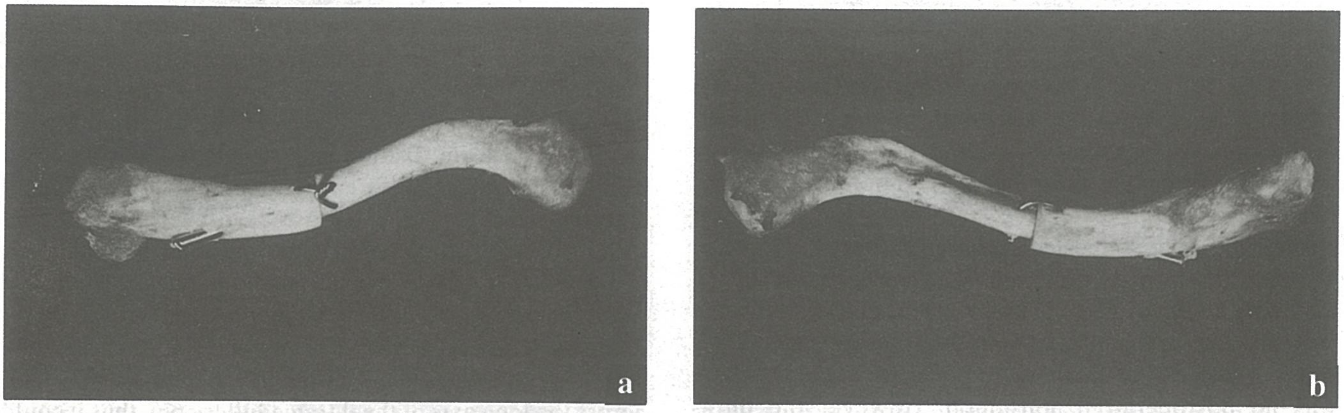


Fig. 7 Failure of the intramedullary pin fixation, supplemented with the intraosseous wire of the clavicular fracture occurred at the fracture site and had elongation of the intraosseous wire.

Table 1 The maximal load and the bending moment of the plating and intramedullary pinning osteosynthesis of the clavicular fracture.

Pairs of clavicles	plating		intramedullary pinning	
	load (N)	bending moment (Nm)	load (N)	bending moment (Nm)
1	229.65	9.19	293.20	11.73
2	288.88	11.56	356.80	14.27
3	282.40	11.29	309.20	12.37
4	323.20	12.93	291.20	11.65
5	334.40	13.38	312.40	12.49
6	348.80	13.95	326.30	13.39
x±S.D.	301.20±43.50	12.05±1.74	314.80±22.10	12.65±0.92

Table 2 The maximal torsional moment in Nm. of each pair of clavicles on which were performed the plating and intramedullary pin fixation, supplemented with the intraosseous wire.

Pairs of clacivles	Torsional force (Nm)	
	plating	intramedullary pinning, supplemented with the intraosseous wire
1	3.88	4.28
2	5.24	4.48
3	4.88	5.36
4	5.20	4.48
x±S.D.	4.82±0.65	4.65±0.48

DISCUSSION

The loss of fixation during healing of the osteosynthesis depends on stability of the fixation and degree of soft tissue injuries. Neer[2] analysed non-union of the fracture clavicle after open reduction and internal fixation caused by extensive soft tissue and periosteal stripping, then he suggested an intramedullary device to be a preferable method of internal fixation because it caused the least amount of surgical trauma. This clinical evidence was the same as Rowe[4] who stated that the intramedullary fixation of the clavicular fracture had encountered, there was no postoperative non-union. However the intramedullary pin fixation of the fracture clavicle acted as only an internal splint to maintain the alignment of the fracture. But the results from the experiment found that the intramedullary pinning osteosynthesis with 3.6 mm. Steimann for the clavicular fracture had no significant differences in the bending moment stability from the plating osteosynthesis. As well the supplement of intramedullary pin fixation with an intraosseous wire had also no significant differences in the torsional moment stability from the plating osteosynthesis despite the intramedullary pin fixation alone haveing no rotational stability. This due to the intraosseous wiring technique provided the interfragmentary compression force and prevented distraction of the racture sites[7]. Furthermore the technique of intraosseous wiring introduced the wire loop across the long axis of the intramedullary pin, thus it could provide some resistance against the rotation between the bone fragments around the pin.

REFERENCES

1. Craig EV. Fracture of the shoulder, Part II. Fracture of the clavicle. In : Rockwood CA, Green DP, Bucholz RW eds. Fracture in adults 3rd ed. Philadelphia, JB Lippinestt, 1991;928-60.
2. Neer CR II. Nonumion of clavicle. JAMA 1960;172:1006-11.
3. Neviaser RJ, Neviaser JS, Neviaser TJ. A simple technique for internal fixation of the clavicle. Clin Orthop 1975;109:103-7.
4. Rowe CR.. An atlas of anatomy and treatment of midclacivular fracture. Clin Orthop 1968;58:29-42.
5. Rucdi TH, Schweiberer L. Clavicular fracture. In : Muller E, Allgower M, Schneider R, Willengger H, 3nd ed. Manual of internal fixation. Berlin Heildelberg New York 1991;434-6.
6. Zennin EJ, Erieg JK, Rosen MJ. Open reduction and internal fixation of clavicle fracture. J Bone Joint Surg(Am) 1981;63:147-51.
7. Zimmerman NB, Weiland AJ. Ninety-ninety intraosseous wiring for internal fixation of the digital skeleton. Orthopaedics 1989;12:99-104.