

# Intramedullary pin fixation in clavicular fractures: A study comparing the use of small and large pins

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## ABSTRACT

The S-shaped clavicle poses a problem for intramedullary pin fixation. Stability of fracture fixation is closely related to the length of intramedullary pin engagement. This study was carried out to determine the engagement length of intramedullary pins into clavicular fractures using a small and a large pin. Seven pairs of fresh cadaveric clavicles were prepared and arranged into Group 1 and Group 2 for paired study. A mid-third clavicular fracture was created at the junction of the two curves of the clavicle. In Group 1, a 3.2 mm diameter threaded Steinman pin was introduced into the medullary canal of the clavicle by retrograde technique and the medial fragment of the fracture was drilled until the pin perforated the bone cortex. In Group 2, a 4 mm diameter threaded Steinman pin was used in the same manner. The results showed that Group 1 had an average engagement of pin into the clavicle of 9.11 cm with a ratio to total length of the clavicle of 0.59. In Group 2, the average engagement length into the clavicle was 7.17 cm with a ratio of 0.47. The difference was significant, with the smaller pin providing better fixation. The pins in both groups perforated the lateral fragment at the posterosuperior aspect and the medial

fragment at the anterior aspect of the clavicle. The angle that the pin made with the long axis of the clavicle in Group 1 was 22.43° and in Group 2, 26.57°. Although the 3.2 mm diameter pin was more aligned to the long axis of the clavicle than the 4 mm diameter pin, the difference was not significant.

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## CLINICAL RELEVANCE

When intramedullary pin fixation for a clavicular fracture is performed, a very large-size pin should not be used. An appropriate pin size is important for greater engagement length of the pin into the fracture fragments. The 3.2 mm diameter pin is preferable because it penetrates 1.95 cm further into the medullary canal

## INTRODUCTION

Intramedullary pin fixation of a clavicular fracture is frequently performed in our centre although there are problems including distraction of the fracture and pin migration.<sup>4,7,10</sup> The function of the intramedullary pin is an internal splint that maintains alignment of the fracture without rigid fixation.<sup>2,10</sup> So, intramedullary

pin fixation mostly uses external immobilization such as a sling or collar and cuff.<sup>5,7</sup> However, the intramedullary pin has many advantages, namely minimal soft tissue dissection and periosteal stripping, small surgical exposure, ease of removal, no skin prominence at the fracture and avoidance of stress shielding.<sup>10</sup> Since the clavicle is S-shaped,<sup>6,8</sup> insertion of an intermedullary pin with sufficient engagement length into the curved medullary canal across the fracture fragments poses a problem. The aim of this study is to measure the engagement length of a small and a large size pin for intramedullary fixation of the clavicular fracture.

#### MATERIALS AND METHOD

Seven pairs of fresh cadaveric clavicles were obtained, their ages ranging from 20 to 30 years. Soft tissues were removed from the bone. The clavicles were arranged into 2 groups for paired study. Each group contained 7 clavicles and had the same number of right and left clavicles. Total lengths of the clavicles and anteroposterior and superoinferior diameter at the junction of the curve of the medial clavicle changing to the curve of the lateral clavicle were recorded (Table 1). These data were analyzed by the Wilcoxon Matched-pairs Signed-Ranks test and no significant difference was found. A middle one-third transverse clavicular fracture was created by saw osteotomy at the junction of medial and lateral clavicular curves. The anteroposterior and superoinferior diameters of the medullary canal at the osteotomy were measured. The lateral fragment was fixed in a horizontal plane by a large metal clamp with the superior aspect upwards.

In Group 1, a 3.2 mm diameter threaded Steinmann pin with a sharp diamond shape at both ends of the pin (Zimmer, Indiana, USA) was introduced into the medullary canal of the lateral fragment of the clavicle by McKeever's technique. Subsequently, the medial fragment was reduced to the lateral fragment. The reduction position was temporarily maintained by placing a 6-hole one-third tubular plate on the superior aspect of the clavicle and fixing the bone fragment to the plate by four small bone clamps, two on the lateral fragment and the other two on the medial fragment. The pin was drilled medially across the fracture site into the medullary canal of the medial fragment of the clavicle until the pin perforated the bone cortex.

In Group 2, a 4 mm threaded diameter Steinmann pin was used instead of the 3.2 mm diameter pin, and the pin was introduced into the medullary canal of the lateral and the medial fragment of the clavicle by

the same technique as Group 1. The length of pin engagement into the lateral and the medial fragment of the fracture was measured from the fracture site to the point of pin perforation of the bone. Total engagement length of the pin in the clavicular fracture was obtained by a summation of the engagement length of the pin into the lateral and the medial fragments of the fracture compared with the length of a reconstruction plate (Synthes Salzach Switzerland). A ratio of the total engaged length of the pin to the length of the clavicle was calculated. The point of pin perforation of the bone was recorded in relation to the aspect of the clavicle. The direction of the pin engaged into the lateral fragment of the clavicle was recorded in relation to the conoid tubercle of the clavicle. On the S-shaped clavicle, the long axis was determined by a line from the center of the sternal and acromion ends of the clavicle. Then, the angle which the pin made with the long axis of the clavicle was measured. The data were analyzed for statistical difference of both groups by the Wilcoxon Matched-Pairs Signed-Ranks test.



**Figure 1** Length of engagement and bone perforation of intramedullary pin fixation of a clavicular fracture.

#### RESULTS

In Group 1, the 3.2 mm diameter intramedullary pin had an average engaged length into the lateral fragment of the clavicle of 4.87 cm (SD 0.69) (Table 1). The pin perforated the bone at the posterosuperior aspect of the lateral fragment of all clavicles. Four pins perforated the fragment lateral to the conoid tubercle of the clavicle, one pin perforated the middle and two pins medial to the tubercle. The pin had an average engaged length into the medial fragment of 4.24 cm

(SD 1.47) (Table 1). The pin perforated the bone at the anterior aspect of the clavicle. Total engaged length of the pin in the clavicle was 9.12 cm (SD 1.13) (Table 1). The length was equivalent to an 8-hole reconstruction plate. The ratio of total pin engagement length to length of the clavicle was 0.59. The angle between the long axis of the pin and the long axis of the clavicle was 22.43° (SD 6.32) (Table 1).

In Group 2, the 4 mm diameter pin had an average engaged length into the lateral fragment of the clavicle of 4.26 cm (SD 0.62) (Table 1). The pin perforated the bone at the posterosuperior aspect of the lateral fragment of all clavicles. The pin perforated the lateral fragment medial to the conoid tubercle in all clavicles. The pin had an average engaged length into the medial fragment of 2.91 cm (SD 1.09) and perforated the bone at the anterior aspect of the clavicle like the smaller pin. The total engaged length of the pin into the clavicle was 7.17 cm (SD 0.88) (Table 1), which was equivalent to a 6-hole reconstruction plate. The ratio of the total engaged length of the pin into the clavicle to the length of the clavicle was 0.46. The angle between the long axis of the pin and that of the clavicle was 26.57° (SD 8.83) (Table 1).

Statistical analysis showed that the 3.2 mm pin had significantly greater depth of penetration (engagement length) into the lateral, medial and combined fragments of the clavicle ( $P = 0.018, 0.028$  and  $0.006$  respectively). Moreover, the engaged length of the 3.2 mm pin into the lateral fragment was not different from the engaged length of the pin into the medial fragment of the clavicle ( $P = 0.6121$ ), whereas the engaged length of the 4 mm pin into the medial fragment of the clavicle was 31.7% shorter than the engaged length of the pin into the lateral fragment ( $P = 0.0425$ ). The long axis of the 3.2 mm pin was more aligned to the long axis of the clavicle than the 4 mm pin, but there was no significant difference ( $P = 0.0519$ ).

## DISCUSSION

The study showed that both 3.2 mm and 4 mm intramedullary pins had a longer engaged length into the lateral fragment than medial fragment, although the engaged length of the 3.2 mm pin into the two fragments of the clavicle was not statistically significant. The 4 mm pin had an engaged length into the lateral fragment 1.45 times longer than the engaged length of the pin into the medial fragment. This can be explained by the anatomical flat shape cross section of the lateral clavicle<sup>6,8</sup> which forms a space in the

medullary canal between bone and pin greater than that of the medial fragment. This permits a flexible intramedullary pin adapting and creeping for a greater distance from the fracture site into the lateral fragment of the clavicle, despite the medullary canal of the lateral fragment being a curve.<sup>6,8</sup> Since the medial fragment is more tubular and has a round shaped cross-section like the cross section of the intramedullary pin, the 4 mm pin occupies almost all the medullary canal of the medial fragment and has less space between cortical bone and pin for adaptation and creeping in the curved medullary canal of the medial fragment.<sup>6,8</sup> When an intramedullary pin has already been introduced into the lateral fragment, the pin makes an angle with the axis of the lateral fragment being fixed so that drilling of the pin across the fracture site is at a fixed angle into the medial fragment of the clavicle. This makes the engaged length of both 3.2 and 4 mm pins into the medial fragment shorter than into the lateral fragment. Penetration of the 4 mm pin into the lateral fragment of the clavicle is still relatively short, and all 4 mm pins perforated the lateral fragment of the clavicle medial to the conoid tubercle while only two of the 3.2 mm pins exited medial to the tubercle.

This study showed that a small intramedullary pin provides a greater length of engagement into the clavicle than a larger pin does. Although the total engaged length of the 4 mm intramedullary pin is shorter than that of the 3.2 mm pin, we think that both sizes of pins can be used for intramedullary fixation of clavicular fractures.<sup>1,3,9</sup> This is because engagement of the 4 mm pin is equivalent to a 6-hole reconstruction plate while that of the 3.2 mm pin is equivalent to an 8-hole reconstruction plate.

Since an intramedullary pin serves the function of a load sharing device,<sup>10</sup> having no rigid fixation, a longer leverage of bending moment is needed in order to improve stability of the fracture fixation. Using a very large and rigid intramedullary pin has the problem of short engaged length into the curved medullary canal of the clavicle, resulting in higher stress at the bone and pin interface, which is an important cause of pin loosening and failure of fixation. Selection of an appropriate pin for security of clavicular fracture fixation should be based on the size of the pin in relation to the size of the medullary canal of the clavicle. Because of the short engaged length of the intramedullary pin into the medial fragment, a threaded pin should be drilled into the medullary canal of the medial fragment until the pin just perforates the anterior cortex of the bone, in order to improve stability of the medial fragment fixation.

**Table 1**  
**Data of seven pairs of clavicles**

No. of pair	Total length (cm)		Diameter of the clavicles at osteotomy site (mm)		Diameter of the medullary canals at osteotomy site (mm)		Pin engage length of lateral fragment (cm)		Pin engage length of medial fragment (cm)		Total engage length of pin (cm)		Angles of pin and clavicular axis (degrees)					
	Group 1	Group 2	Superoinferior Group 1	Anteroposterior Group 2	Superoinferior Group 1	Anteroposterior Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2				
1	14.33	14.60	0.95	1.18	1.30	1.25	6.30	7.40	8.20	8.00	3.60	3.38	5.63	2.88	9.29	6.26	21	23
2	15.60	15.53	1.03	1.10	1.15	1.35	7.80	7.20	7.70	7.60	5.78	5.28	2.48	1.38	8.26	6.66	28	39
3	14.90	14.83	1.05	1.00	1.35	1.43	6.50	6.20	6.70	7.60	5.00	4.08	5.05	2.58	10.05	6.66	17	25
4	16.10	16.40	0.93	1.10	1.48	1.30	6.00	5.30	7.10	6.50	5.00	4.78	3.50	1.98	8.50	6.76	34	39
5	15.25	15.53	0.98	0.98	1.25	1.25	4.40	4.60	7.30	7.40	4.40	3.83	4.60	3.73	9.00	7.56	19	23
6	14.70	14.50	0.98	0.83	1.13	1.05	5.90	4.90	7.00	6.80	5.30	4.23	2.40	3.15	7.70	7.38	21	19
7	16.00	15.60	1.05	1.03	1.10	1.13	5.10	5.20	6.8.0	6.80	5.00	4.23	6.03	4.68	11.03	8.91	17	18
Average	15.27	15.28	1.00	1.03	1.25	1.25	6.00	5.83	7.26	7.24	4.87	4.26	4.24	2.91	9.12	7.17	22.43	26.57
SD	0.67	0.68	0.05	0.11	0.14	0.13	1.07	1.12	0.53	0.55	0.69	0.62	1.47	1.09	1.13	0.89	6.32	8.83

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