



# Surgical approach for open reduction and internal fixation of clavicle fractures: a comparison of vertical and horizontal incisions

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## Abstract

**Purpose** This study was designed to compare the results of clavicle fracture open reduction internal fixation (ORIF) with standard horizontal incision versus vertical incision.

**Methods** ORIF surgery performed between October 2012 and August 2016 was included. The surgical approach was chosen according to surgeon preference as vertical or horizontal. Functional outcomes, fracture union, complications, scar appearance, skin irritation, and denervation around the scar were assessed at a minimum follow-up of three months.

**Results** Thirty-eight patients, age  $39 \pm 12$  years, were operated upon, 22 through vertical incisions and 16 through horizontal incisions. There were no significant group differences in functional scores, fracture union, or complications. Two patients in the vertical incision group had a post-operative haematoma. The scar length was significantly shorter when a vertical incision was used ( $6.75 \pm 1.25$  cm vs  $8.9 \pm 2.3$  cm,  $P = 0.001$ ). The typical distribution of hypoesthetic skin area distal and lateral to the scar represented iatrogenic damage to the supraclavicular nerves and was found in 66% of patients. The mean hypoesthetic surface area was smaller in the vertical incision group ( $38 \pm 29$  cm<sup>2</sup> vs  $48 \pm 28$  cm<sup>2</sup>,  $P =$  non-significant).

**Conclusion** Vertical incision results in shorter scars but may be associated with increased incidence of haematomas. Meticulous closure of the subcutaneous tissue is recommended.

**Keywords** Clavicle fractures · Open reduction and internal fixation · Vertical and horizontal incisions

## Introduction

Clavicle fractures account for 2.5% of all fractures among adults and often affect young active adults as well. In the department of emergency or orthopaedics, fractures of the clavicle were a common injury, constituting 2.6–10% of all fractures and 35–44% of all shoulder girdle injuries [1]. The majority of these fractures can be treated non-surgically, but some require fixation, mostly those involving the distal third and fractures with gross displacement of the fragments. Open reduction internal fixation (ORIF) is usually carried out using plates and screws. While surgery unites the fractured parts of

the limb and reconstructs the anatomy, it is associated with skin irritation and numbness that often leads to re-operation for removal of the plate [2–5]. The common surgical approach to the clavicle is a horizontal incision along the long axis of the bone. This approach, however, is associated with a high risk of damaging branches of the supraclavicular nerves. The position of the horizontal scar is visible and may be irritated by shoulder straps when carrying bags [4]. The infra-clavicular approach uses a similar horizontal incision positioned anterior and inferior to the clavicle and places the scar in a less visible and less vulnerable position [3]. Zhang et al. described an alternative minimally invasive plate osteosynthesis technique (MIPO) for displaced midshaft clavicular fractures (DMCFs) with the application of our self-designed clavicle reductor [6]. Vertical incisions have the potential advantage of decreasing the likelihood to damage the supra-clavicular nerves. They also follow the Gruen lines and thus have the potential of a better cosmetic result. However, a vertical incision allows limited intra-operative exposure of the clavicle fragments

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and may require extensive subcutaneous dissection medially and laterally to gain better exposure of the bone [5].

This study aimed to compare the ORIF results of clavicle fractures following two surgical approaches, standard horizontal incisions and vertical incisions, by the same surgical team in a single medical centre.

## Methods

This study was approved by the institutional ethics committee. Patients (age 18–65) admitted to the hospital with clavicle fractures indicated for surgical fixation, between October 2012 and August 2016, were included in the study. Exclusion criteria were open fractures, additional fractures in the same extremity, and any pre-operative neurologic deficit.

All patients were then allocated to one of three shoulder surgeons according to their date of admission, and the surgical approach was chosen as per the surgeon's preference. All surgeons were experienced fellowship-trained shoulder surgeons.

## Surgical technique

All patients were operated upon in a beach chair position and with the use of an image intensifier. Prophylactic antibiotics were given intravenously 30 minutes before the incision. An anatomic locking compression plate was used (ACUMED, Hillsboro, OR, USA or VariAx, Stryker, Kalamazoo, MI, USA) and placed in a superior position (Fig. 1). A minimum of three screws were placed on each side of the fracture site. The horizontal incision was centered over the fracture site superior to the clavicle and extended medially and laterally to allow full exposure of the bone. The branches of the supraclavicular nerve were protected after they had been identified (Fig. 2). The vertical incision was made over the fracture, and medial and lateral full-thickness skin flaps were created and retracted, after which the muscle was split horizontally, parallel to the bone. Following each procedure, the skin was closed using continuous intradermal absorbable suture (Monocryl 3/0, Ethicon, Somerville, NJ, USA).

## Follow-up

Patients were followed for a minimum of three months. Functional outcomes were assessed using the American Shoulder and Elbow Surgeons (ASES) score and measurements of shoulder range of motion. Fracture union was determined clinically and radiographically. The scar was assessed objectively using the Vancouver scar scale [7] and subjectively using the POSAS scale [8]. Loss of sensation (hypoesthesia) was examined manually around the scar and compared to the contralateral side. The area demonstrating any loss of sensation was marked and the surface area was

calculated. All scars were photographed, and the cosmetic appearance was subjectively assessed by three independent examiners using a (VAS) analog scale, where 1 represents normal skin and 10 the least normal skin. Complications were recorded at the final follow-up.

## Statistical analysis

A power analysis was performed based on our pilot data showing 67% of skin numbness and compared to the data by Wang et al. showing 21% only. Based on this analysis a sample size of 34–38 patients was chosen. SPSS<sup>®</sup> Version 21.0 software was used for data collection and analysis. Postoperative outcomes were retrieved and analyzed. Data are presented as mean  $\pm$  standard deviation (SD). *P* values  $<$  0.05 were considered statistically significant.

## Results

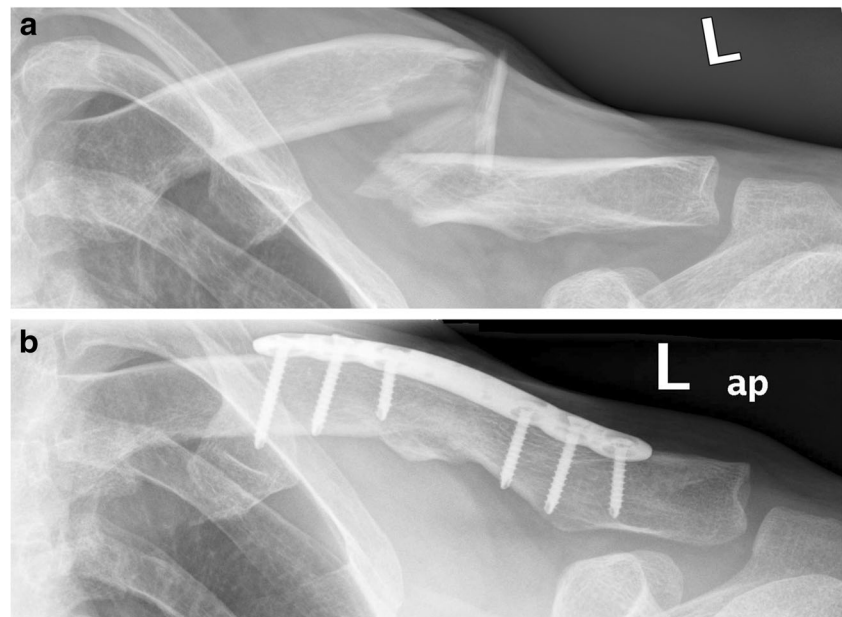
Thirty men and eight women were included in the study. Their mean age ( $\pm$  standard deviation) was  $39 \pm 12$  years, and the mean follow-up time was  $9.2 \pm$  ten months. A similar distribution of fracture types was found in both groups (Table 1). Most (92%) of the patients reported they were satisfied from the results of the operation, and 97% reported that they would do it again. The mean ASES score was  $85.3 \pm 14$ , the mean Vancouver scar scale score was  $2.4 \pm 2$ , and the mean POSAS scar scale was  $4.1 \pm 2.8$  (Table 1).

Of the 38 patients included in the study, 22 were operated upon by means of a vertical incision and 16 by means of a horizontal incision. The scar length was significantly shorter when a vertical incision was used ( $6.75 \pm 1.25$  cm vs  $8.9 \pm 2.3$  cm for the horizontal incision,  $P = 0.001$ ). (Table 1). There were no significant differences between the two groups in the incidence of skin hypoesthesia (64% for vertical incisions vs 69% for horizontal incisions). The typical distribution of skin hypoesthesia was distal and lateral to the scar, and it represented iatrogenic damage to the supra-clavicular cutaneous nerve branches (Fig. 3). The mean surface area of skin hypoesthesia was smaller in the vertical incision group ( $38 \pm 29$  cm<sup>2</sup> compared to  $48 \pm 28$  cm<sup>2</sup> for the horizontal incision group), but the difference was not statistically significant (Table 1).

Cosmetic scores were better in the vertical incision group compared to those in the horizontal group, but not to a level of statistical significance ( $2.43 \pm 1.3$  vs  $2.95 \pm 0.82$  VAS objective,  $3.6 \pm 2.8$  vs  $4.7 \pm 3.1$  POSAS subjective) (Table 1).

There were two cases of non-union, one in each group, and both were re-operated successfully and achieved fracture union. There was one more case of delayed union in the horizontal incision group, and fracture union was achieved without intervention at four months after the operation.

**Fig. 1** Clavicle fracture middle third (a) treated by open reduction and internal fixation with anatomic plate (b)



Six patients in the vertical incision group (and none in the horizontal incision group) complained of scar irritation. Two of those patients were re-operated upon in order to remove the plate on their request. Two patients in the vertical incision group had a post-operative haematoma: it was evacuated in the outpatient clinic two weeks following surgery (Fig. 4). There were no infections or re-fractures among any of the study patients.

## Discussion

The aim of this study was to compare two types of surgical approaches to the clavicle bone in order to carry out open reduction and internal fixation of clavicle fractures. A vertical incision was compared to the standard horizontal incision.

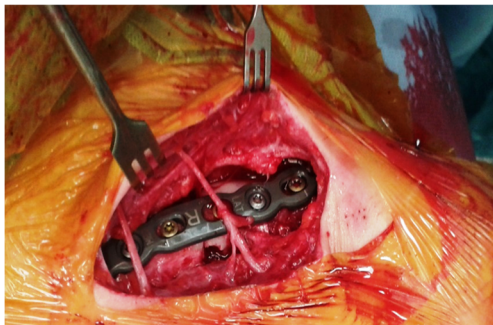
The principal result of this study is that functional outcomes and major complications are similar with both surgical approaches. However, six patients in our vertical incision group complained of skin irritation and numbness compared to none in our horizontal incision group. This is considered a

minor complication reported in up to 10–68% of patients in different studies [4, 5, 9]. The vertical incision has the potential for a better cosmetic outcome by following the Gruen skin lines [5] and thus may be preferred by surgeons and patients.

Branches of the supraclavicular nerve arise from behind the posterior border of the sternocleidomastoid, pierce the platysma, and cross the clavicle along its lateral two thirds. There is a safe zone 2.7 cm lateral to the sternoclavicular joint and 1.9 cm medial to the acromioclavicular joint, leaving the nerve branches prone to damage during surgery to all fractures of the middle third of the clavicle [4].

In a study similar to ours that compared vertical and horizontal incisions in the repair of clavicle fractures, Wang et al. found skin numbness to be present in only 21% of patients with vertical incisions compared to 62% with longitudinal/horizontal incisions. They also found the severity of self-reported numbness to be less significant. Those authors concluded that patients should be warned about this complication (numbness) and that the utilization of a vertical incision can result in reduced numbness and thus may avoid some cases of patient dissatisfaction [5].

In the current study, the incidence of skin numbness was 64% for vertical incisions and 69% for horizontal incisions, and 66% of all incisions in combination. The vertical incision resulted in a shorter scar ( $6.75 \pm 1.25$  cm vs  $8.9 \pm 2.3$  cm) and possibly less damage to the supraclavicular nerves (area of numbness  $38 \pm 29$  cm<sup>2</sup> vs  $48 \pm 28$  cm<sup>2</sup>), as well as a trend toward a better cosmetic result (VAS  $2.43 \pm 1.3$  vs  $2.95 \pm 0.82$ ), but it was associated with more complications. Those complications included early post-operative haematoma formation and late skin irritation leading to re-operation and plate removal. Similarly, Beirer et al. [7] found the area of chest wall numbness to be  $26 \pm 23.7$  cm<sup>2</sup> following conventional



**Fig. 2** Supraclavicular nerves exposed and preserved using a horizontal incision approach to the left clavicle

**Table 1** Patient demographics and outcomes

	Horizontal incision ( <i>n</i> = 16)	Vertical incision ( <i>n</i> = 22)	All patients ( <i>n</i> = 38)
Age, years (range)	41 (25–65)	38 (17–69)	39 (17–69)
Gender, males	12 (75%)	18 (82%)	30 (79%)
Follow-up, months (Range)	7.4 (3–32)	10.5 (3–36)	9.2 (3–36)
Fracture classification (AO)			
15.1 A	9	5	14
15.2 A	4	5	9
15.2 B	9	6	15
Patient satisfaction*	16 (100%)	19 (86%)	35 (92%)
ASES score	84 (53–99)	86 (52–100)	85 (52–100)
Abduction, unit (Range)	160 (90–180)	168 (140–180)	164 (90–180)
External rotation, unit (range)	70 (50–80)	63 (30–90)	65 (30–90)
Complications <sup>†</sup>			
Nonunion	1	1	2
Delayed Union	1	0	1
Scar Irritation	0	6	6
Plate Removal	0	2	2
Hematoma	0	2	2
Scar length (cm) <sup>†</sup>	9 (6–15)	6.75 (5–9)	7.7 (5–15)
Scar width (mm)	2.85 (1–7)	3 (1–6)	2.9 (1–7)
Vancouver scar scale	2.1 (0–5)	2.6 (0–10)	2.4 (0–10)
POSAS scar scale	4.7 (1–10)	3.6 (1–8)	4.1 (1–10)
Scar VAS	2.95 (1.3–4.5)	2.43 (0.6–6.5)	2.65 (0.6–6.5)
Skin denervation	69%	64%	66%
Denervation area (cm <sup>2</sup> )	48 (12–105)	38 (6–89)	42 (6–105)

ASES, American Shoulder and Elbow Surgeons; VAS, visual analog scale: 1 = normal skin and 10 = least normal skin

\*Patient satisfaction score

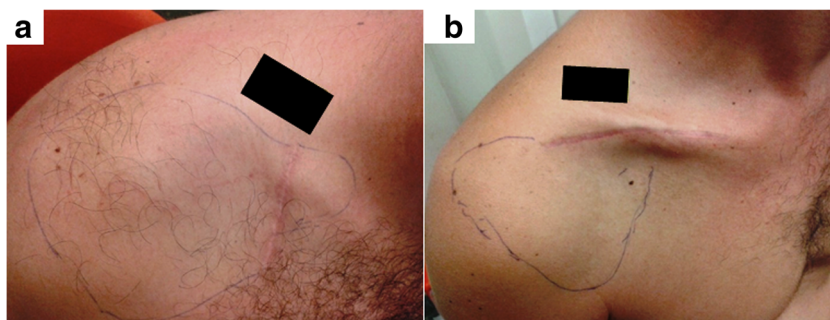
<sup>†</sup>  $P < 0.05$

open clavicle plating. These results are not completely in agreement with those reported by Wang et al. [5]. While the incidence of skin numbness was similar to that reported by Wang et al. for the longitudinal incision and to that reported by Hulsmans et al. for superior (68%) and antero-inferior (51%) incisions [9], they were significantly higher than the incidence of skin numbness reported for the vertical incision. Differences in positioning of the incision as well as subcutaneous dissection may be responsible for those differences.

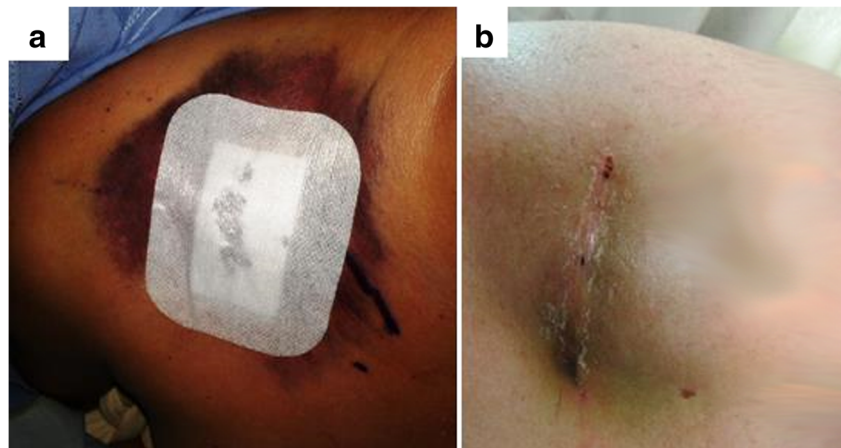
Wang et al. reported that the vertical incision was inclined slightly toward the estimated orientation of the supraclavicular nerves [5]. Furthermore, those authors used subjective self-reported outcome to grade the degree of numbness, while we used both an objective surface area measure to quantify the degree of supraclavicular nerve damage and the POSAS subjective score.

Wang et al. clinically observed that numbness and skin irritation became diminished over time, but those parameters

**Fig. 3** Area of skin denervation lateral and distal to the surgical scar using **a** a vertical approach and **b** a horizontal approach



**Fig. 4** Early post-operative haematoma formation using the vertical approach to the clavicle. **a** One-day post-operative haematoma [patient A] and **b** 2-week post-operative haematoma [patient B]



were not specifically addressed and could not be confirmed during the study. Berier et al. also found the area of numbness to diminish from  $26.0 \pm 23.7 \text{ cm}^2$  after surgery to  $19.8 \pm 17.0 \text{ cm}^2$  at the six month follow-up, raising that possibility that the timing of the follow-up evaluation may be responsible for different results between studies [10]. Berier et al. also suggested the use of a mini-open approach to the clavicle, resulting in significantly shorter incisions and significantly less skin numbness [10]. A recent study by Calbiyik et al. [11] examined whether minimal invasive implantation of a novel intramedullary device (group 1) produces comparable outcomes with LCP fixation (group 2) in patients with displaced midshaft clavicle fractures. They found that cosmetic dissatisfaction was significantly less common in group 1 than that in group 2 (1 patient (2.9%) vs. 14 patients (35.0%), respectively,  $P < 0.001$ ). Unsatisfactory outcomes including skin irritation, dysesthesia, delayed union, and painful shoulder were quite rare, and their occurrence rate was not significantly different between the two groups.

The rate of plate removal in the current study (2/38) is low compared to those of other studies. Hulsmans et al. reported a 43% rate of plate removal and found that age  $< 40$  years to be an independent factor for plate removal [9]. The low rate of plate removals in our study may be related to a relatively short follow-up period and to a more conservative approach toward this procedure. A non-union rate in this study was similar to that described in the literature [12].

Limitations of our study include possible selection bias due to method of patient's allocation to study group by surgeon's preference. While allocation was not random, each surgeon chose the surgical technique he was most familiar and comfortable with avoiding complications related to unfamiliarity with the approach. The relatively small number of patients does not allow the demonstration of statistically significant differences for most of the outcomes. The short follow-up period does not allow arriving at firm conclusions on long-term results (although the main expected differences between the approaches are not believed to affect long-term results).

## Conclusions

Surgeons should carefully weigh the cosmetic benefits of a vertical scar with the possible increased rate of complications associated with that approach. Care should be given to meticulous closure of the subcutaneous tissue to prevent hematoma formation in both vertical and horizontal incisions in ORIF clavicle.

## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethical approval** This retrospective study was approved by the Institutional Review Board.

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