

# Cutaneous paresthesia after internal plate fixation of clavicle fractures and underlying anatomical observations

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## Abstract

To assess the clinical and anatomical causes of cutaneous paresthesia after internal fixation of clavicle fractures.

This study included 135 patients who underwent internal fixation of clavicle fractures from May 2013 to June 2016 at the First and Second Affiliated Hospital of Guangxi Medical University. The incidence of postoperative supraclavicular nerve injury, the duration of numbness, and improvements after plate removal were retrospectively analyzed. Seven human cadaver specimens were subsequently dissected to analyze the supraclavicular nerve and its relationship to numbness.

Of the 135 patients who underwent internal fixation of clavicle fractures, 26 (19.3%) experienced postoperative cutaneous paresthesia, with 22 (16.3%) and 4 (2.8%) experiencing numbness and pain, respectively. The most intense numbness occurred during the first operative month. Of the 22 patients with numbness, 1 (4.5%), 1 (4.5%), and 20 (90.1%) patients reported mild, moderate, and severe numbness, respectively. Two patients described increased awareness of numbness when in contact with clothes, 2 were psychologically affected by numbness, and 20 (90.1%) reported reduced severity of numbness over time. At the last follow-up, numbness was found to persist in 2 (1.5%) patients. None of the patients was bothered by numbness. Cadaver dissection showed that the supraclavicular nerve emerged from the 1/2 posterior edge of the cervical sternocleidomastoid muscle and subsequently divided into 3 branches, with the lateral branch  $2.26 \pm 1.17$  cm from the lateral margin of the acromion, the middle branch near the mid-clavicle, and the medial branch  $2.03 \pm 0.85$  cm from the sternal lateral margin.

Cutaneous paresthesia is common following internal fixation of the clavicle. Anatomic analysis showed that the nerve could be easily injured during clavicle operation. Numbness improved in most patients, but persisted for up to 2 years and was even permanent in a few. Most patients considered numbness as an insignificant factor in their daily lives.

**Keywords:** anatomy, clavicle fracture, cutaneous paresthesia, numbness, plate internal fixation, supraclavicular nerve

## 1. Introduction

Clavicle fracture is one of the most frequent types of bone fracture. If not treated, clavicle fracture can lead to long-term pain, shoulder dysfunction, and/or fracture nonunion.<sup>[1,2]</sup> Fracture without dislocation and without peripheral tissue damage can be conservatively treated without complications.<sup>[3,4]</sup> Surgical treatment of clavicle fractures is becoming more widespread, as it relieves pain more quickly and is more precise than conservative treatment methods.<sup>[5,6]</sup> Levels of functional

recovery and satisfaction following surgical treatment of clavicle fracture are much higher than those following other types of surgery.<sup>[7]</sup> Surgery is also recommended for comminuted and shortened deformity fractures, except for open fractures and fractures accompanied by neurovascular injury.<sup>[8]</sup> Clavicle fractures can be treated by plate internal fixation or intramedullary nailing, depending on patient age, sex, accompanying clinical conditions, and demands for postoperative functional recovery.<sup>[9,10]</sup> Functional recovery and the incidence of complications, however, did not differ significantly following these 2 types of surgery.<sup>[11–14]</sup>

Lack of proper protection of the supraclavicular nerve can lead to nerve injury, causing sensory abnormalities in the clavicle area, including numbness, pain, and hypersensitivity. The increasing incidence of clavicle fractures has led to increases in the rates of clavicle nerve injury, numbness, and pain after open reduction and internal fixation.<sup>[15,16]</sup> However, the prognosis of patients with numbness after surgery remains to be clarified.

The current study assessed outcomes in 135 patients who underwent internal fixation of clavicle fractures with regard to postoperative numbness. Furthermore, several cadavers were dissected to show the anatomic distribution of supraclavicular sensory nerve innervation.

## 2. Materials and methods

This study included 135 patients who underwent internal fixation of clavicle fractures by standard horizontal skin incisions at the First and Second Affiliated Hospital of Guangxi Medical

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University from May 2013 to June 2016 (149 patients were nonoperatively treated in the same time span). Indications for surgical treatment of clavicle fractures include the following: the absence of bone healing; neurovascular injury; lateral clavicle fracture combined with coracoclavicular ligament tear; soft tissue embedded between fractures; and floating shoulder.<sup>[1]</sup> At least 3 screws were used for plate fixation of each main fragment (Fig. 1A and B). This study was approved by the Ethics Committee Board of Guangxi Medical University (Ethical approval No.: 2013[KY-E-53]). All the participants provided their written informed consent to participate in this study.

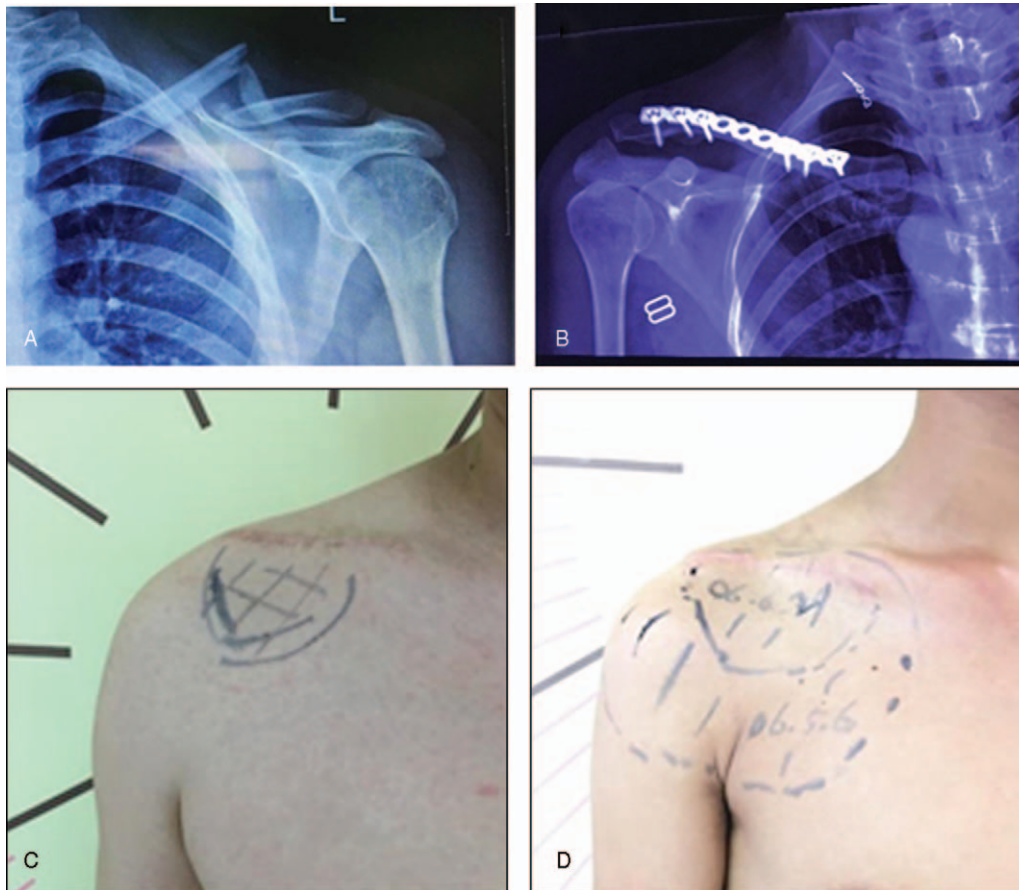
Patients were administered questionnaires by telephone and during outpatient visits. Data regarding postoperative numbness around the scar (Fig. 1C) and its impact on daily life were analyzed. Questionnaires contained questions on the occurrence of numbness and its functional impact on daily life after clavicle surgery (Table 1), the natural history of numbness after clavicle surgery (Table 2), and pain after clavicle surgery and numbness after surgery for implant removal (Table 3).

Seven cadavers (6 males and 1 female), ranging in age from 30 to 60 years, were obtained from the Department of Anatomy of Guangxi Medical University. The cadavers used by the Department of Anatomy of our institution for research and educational purposes were assigned to this project with permission given by their next-of-kin(s). Their clavicle areas showed no congenital malformations.

**3. Results**

We included 135 patients under internal fixation of clavicle fracture, from May 2013 to June 2016 in the First and Second Affiliated Hospital of Guangxi Medical University. There were 45 female and 90 male patients, of mean  $\pm$ SD age  $39 \pm 2.7$  years (range, 8–77 years) and mean  $\pm$ SD follow-up time  $21.6 \pm 8.8$  months (range, 6–47 months). Implants were removed from 29 patients at an average  $12.5 \pm 10.2$  months (range, 3–34 months). Detailed follow-up data are shown in Supplemental Table 1, <http://links.lww.com/MD/C537>.

Four patients (3.0%) reported postoperative pain, 2 with mild, one with moderate, and one with severe pain (Fig. 2A). The incidence of postoperative numbness was 16.3% (22/135, Fig. 2A), with 20 of these 22 patients (91%) reporting improvements in numbness severity over time (Fig. 1D). Only 2 patients reported constant numbness up to the last follow-up. Of the 22 patients with postoperative numbness, 7 reported that numbness was worst during the first postoperative month, with one patient each reporting that numbness was worst during the second, third, sixth, tenth, and twelfth months. Of the 22 patients with numbness, one (4.5%), one (4.5%), and 20 (90.1%) patients reported mild, moderate, and severe numbness, respectively (Fig. 2B). Only 2 patients experienced increased awareness of numbness during contact with straps or clothes, with both having mild numbness. None of the 22 patients with numbness was significantly bothered by the numbness, even



**Figure 1.** Representative surgical findings and determination of areas of sensory abnormality. (A) Preoperative x-ray images of a clavicle fracture. (B) Postoperative x-ray images of plate internal fixation of a clavicle fracture. (C) Photograph of a patient presenting to the outpatient department for numbness of fracture clavicle following plate fixation. (D) Photograph of the same patient, showing improvements over time of numbness of the fracture clavicle at the scar site following plate fixation.

| Table 1  |                              |
|--|------------------------------|
| Follow-up occurrence and functional impact of numbness on daily life after clavicle surgery. |                              |
| Question   | Reply                        |
| Any numbness below operation scar?   | Yes, No                      |
| Severity of numbness now?  | None, Mild, Moderate, Severe |
| More aware of numbness when scar touched?  | Yes, No                      |
| Bothered by numbness in daily life?  | No, Mild, Moderate, Severe   |

| Table 2  |   |
|--|---|
| Natural history of numbness after clavicle surgery.                  |   |
| Question   | Reply                                     |
| Did numbness become worse, remain the same, or improve?              | Became worse, Remained the same, Improved |
| When was the numbness at its worst?                                  | Time (months after surgery)               |
| At its worst, were you more aware of numbness when scar touched?     | Yes, No                                   |
| At its worst, was the severity of numbness exacerbated when touched? | None, Mild, Moderate, Severe              |
| At its worst, were you bothered by the numbness in daily life?       | None, Mild, Moderate, Severe              |

| Table 3   |                              |
|---|------------------------------|
| Pain after clavicle surgery and numbness after surgery for implant removal. |                              |
| Question  | Reply                        |
| Any pain below the scar area?   | Yes, No                      |
| Severity of pain?   | None, Mild, Moderate, Severe |
| Changes in numbness after implant removal?                                  | No change, Relieved, Worse   |

when at its worst. At a mean follow-up of 21.6 months, the incidence of numbness decreased over time, but 2 patients (1.5%) reported long-lasting numbness. Removal of implanted plates did not have a relevant effect on numbness.

To assess the anatomic features of postoperative numbness after clavicle fracture, we dissected 7 cadavers, 6 men and 1 woman, ranging in age from 30 to 60 years. Dissection showed

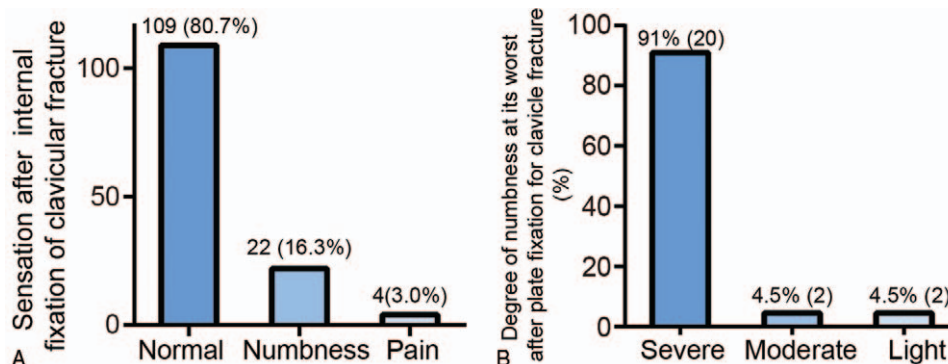
that the supraclavicular nerve emerged from the 1/2 posterior edge of the cervical sternocleidomastoid muscle and divided into 3 branches. Measurements showed that the lateral branch was  $2.26 \pm 1.17$  cm from the lateral margin of the acromion, the middle branch was near the mid-clavicle, and the medial branch was  $2.03 \pm 0.85$  cm from the sternal lateral margin. The 3 branches of the supraclavicular nerve showed a regular distribution. None of these cadavers had a missing or additional branch (Fig. 3).

#### 4. Discussion

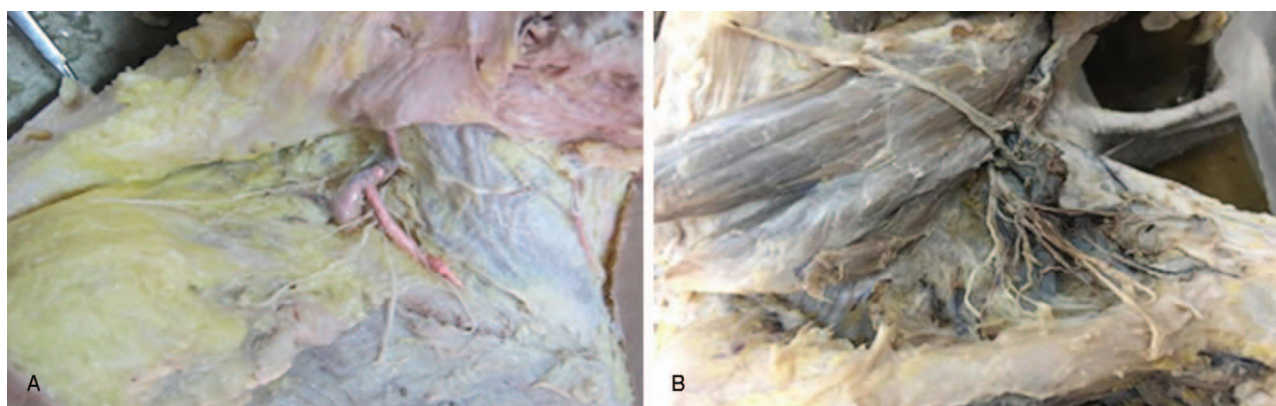
Clavicle fracture is one of the most common types of fractures, accounting for 2.6% to 4% of clinical fractures.<sup>[17]</sup> Although internal fixation is the usual treatment of choice, complications induced by supraclavicular nerve damage, including numbness, pain, and other sensory loss, may be neglected. Because the supraclavicular nerve is located above the front of the clavicle,<sup>[18]</sup> surgery may result in injury, leading to permanent numbness around the scar. The present study retrospectively analyzed 135 patients who underwent internal fixation for clavicle fractures. Only 2 patients experienced sensory decline, whereas numbness in the remainder improved over time. The incidence of numbness (16.3%) after plate fixation was within the reported range (12%–29%).<sup>[19,20]</sup> Other studies found that the incidence of numbness was higher (46%–55.6%) than the normal range.<sup>[21,22]</sup> This discrepancy may have been due to the small sample size of the earlier studies or their inclusion of other ethnic groups.

Analysis of its natural history showed that clavicle hypoesthesia was at its worst during the first postoperative month. This was not surprising, as patients usually start to notice numbness after the relief of postoperative pain. Patients were informed preoperatively about the symptoms and duration of complications such as numbness, as well as their impact on daily life. Despite the severity of numbness, no patient was bothered by numbness even at its worst time. Two patients reported numbness at last follow-up, a duration of 2 years. Longer term follow-up studies are needed to determine whether numbness dissipates completely over time.

Patients with supraclavicular nerve compression have also been described.<sup>[23]</sup> Neuroma induced by iatrogenic injury, compression, and over stretching following clavicle fracture could lead to severe pain, sensory loss, or numbness. These patients require nerve release surgery to relieve these symptoms.



**Figure 2.** Cutaneous hypoesthesia after internal fixation of clavicle fracture. (A) Comparison of patients with normal findings, numbness, and pain sensation after internal fixation of clavicle fractures. Percentage (N=number of patients). (B) Bar diagram showing the natural history of worst degree of numbness after plate fixation for clavicle fracture. Percentage (N=number of patients).



**Figure 3.** Photograph showing the supraclavicular nerve in a fresh cadaver specimen.

In the present study, some patients reported numbness, even after 2 years, suggesting that these patients may have neuroma.

Diaphyseal fractures are responsible for 69% to 82% of clavicle fractures; 21–28% of fractures of the lateral third; and 2% to 3% of fractures of the middle third.<sup>[1,24,25]</sup> A retrospective analysis of 309 clavicle fractures and their relation to supraclavicular nerve injury after trauma<sup>[26]</sup> found that all patients showed spontaneous improvement, at a mean 3 months after the trauma. Injuries to the medial, middle, and lateral branches of the supraclavicular nerve could lead to an abnormal feeling in the chest. Knowing the regular distribution of the supraclavicular nerves could avoid injuries to these nerves. Our dissection of 7 cadavers showed the anatomical structure of the supraclavicular nerve, providing evidence of injury after fixation surgeries of clavicle fractures.

The limitations of this study included the relatively small number of patients included and the retrospective methodology. Patients provided subjective symptomatology, but objective measures were not provided. Objective measures of cutaneous hypoesthesia would require sophisticated neurophysiological examinations with special instruments.

In summary, cutaneous sensory paresthesia is a common symptom after internal fixation of the clavicle. Numbness improves in most patients over time, but may persist for up to 2 years postoperatively. Cutaneous hypoesthesia may be caused by injury to the supraclavicular nerve resulting from the fracture or from the surgery itself. The anatomy of the supraclavicular nerve is clear. Careful exposure and delamination of these nerves during surgery can protect the nerve, resulting in satisfactory postoperative outcomes.

### Author contributions

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**Investigation:** Liping Yang.

**Methodology:** Jinmin Zhao.

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**Writing – review & editing:** Wei Su.

### References

- [1] Postacchini F, Gumina S, De Santis P, et al. Epidemiology of clavicle fractures. *J Shoulder Elbow Surg* 2002;11:452–6.
- [2] Sambandam B, Gupta R, Kumar S, et al. Fracture of distal end clavicle: a review. *J Clin Orthop Trauma* 2014;5:65–73.
- [3] Oliveira ASJ, Roberto BB, Lenza M, et al. Preferences of orthopedic surgeons for treating midshaft clavicle fracture in adults. *Einstein (Sao Paulo)* 2017;15:295–306.
- [4] Shukla A, Sinha S, Yadav G, et al. Comparison of treatment of fracture midshaft clavicle in adults by external fixator with conservative treatment. *J Clin Orthop Trauma* 2014;5:123–8.
- [5] Duprey S, Bruyere K, Verriest JP. Clavicle fracture prediction: simulation of shoulder lateral impacts with geometrically personalized finite elements models. *J Trauma* 2010;68:177–82.
- [6] Bonneville N, Delannis Y, Mansat P, et al. Bilateral clavicle fracture external fixation. *Orthop Traumatol Surg Res* 2010;96:821–4.
- [7] Rasmussen JV, Jensen SL, Petersen JB, et al. A retrospective study of the association between shortening of the clavicle after fracture and the clinical outcome in 136 patients. *Injury* 2011;42:414–7.
- [8] Ding M, Hu J, Ni J, et al. Iatrogenic subclavian arteriovenous fistula: rare complication of plate osteosynthesis of clavicle fracture. *Orthopedics* 2012;35:e287–9.
- [9] Stark MJ, DeFranco MJ. Elastic intramedullary nailing of a medial clavicle fracture in a pediatric patient. *Case Rep Orthop* 2017;2017:6354284.
- [10] Xu B, Lin Y, Wang Z, et al. Is intramedullary fixation of displaced midshaft clavicle fracture superior to plate fixation? Evidence from a systematic review of discordant meta-analyses. *Int J Surg* 2017;43:155–62.
- [11] Zarkadis NJ, Eisenstein ED, Kusnezov NA, et al. Open reduction-internal fixation versus intramedullary nailing for humeral shaft fractures: an expected value decision analysis. *J Shoulder Elbow Surg* 2018;27:204–10.
- [12] Pennock AT, Bastrom TP, Upasani VV. Elastic intramedullary nailing versus open reduction internal fixation of pediatric tibial shaft fractures. *J Pediatr Orthop* 2017;37:e403–8.
- [13] Kose A, Aydin A, Ezirmik N, et al. A comparison of the treatment results of open reduction internal fixation and intramedullary nailing in adult forearm diaphyseal fractures. *Ulus Travma Acil Cerrahi Derg* 2017;23:235–44.
- [14] Bellringer SF, Gee C, Wilson DG, et al. Avoiding open reduction and internal fixation in the intramedullary nailing of subtrochanteric femoral fractures. *Ann R Coll Surg Engl* 2015;97:242–3.
- [15] Kihlstrom C, Moller M, Lonn K, et al. Clavicle fractures: epidemiology, classification and treatment of 2 422 fractures in the Swedish Fracture Register; an observational study. *BMC Musculoskelet Disord* 2017;18:82.
- [16] van Laarhoven JJ, Ferree S, Houwert RM, et al. Demographics of the injury pattern in severely injured patients with an associated clavicle fracture: a retrospective observational cohort study. *World J Emerg Surg* 2013;8:36.
- [17] Bhattacharyya R, Jayaram PR, Holliday R, et al. The virtual fracture clinic: reducing unnecessary review of clavicle fractures. *Injury* 2017;48:720–3.
- [18] Abo El Nor T. Displaced mid-shaft clavicular fractures: surgical treatment with intramedullary screw fixation. *Arch Orthop Trauma Surg* 2013;133:1395–9.

- [19] Canadian Orthopaedic Trauma S Nonoperative treatment compared with plate fixation of displaced midshaft clavicular fractures. A multicenter, randomized clinical trial. *J Bone Joint Surg Am* 2007;89:1–0.
- [20] Shen WJ, Liu TJ, Shen YS. Plate fixation of fresh displaced midshaft clavicle fractures. *Injury* 1999;30:497–500.
- [21] Wang K, Dowrick A, Choi J, et al. Post-operative numbness and patient satisfaction following plate fixation of clavicular fractures. *Injury* 2010;41:1002–5.
- [22] Wang L, Ang M, Lee KT, et al. Cutaneous hypoesthesia following plate fixation in clavicle fractures. *Indian J Orthop* 2014;48:10–3.
- [23] O'Neill K, Stutz C, Duvernay M, et al. Supraclavicular nerve entrapment and clavicular fracture. *J Orthop Trauma* 2012;26:e63–5.
- [24] Robinson CM. Fractures of the clavicle in the adult. Epidemiology and classification. *J Bone Joint Surg Br* 1998;80:476–84.
- [25] Stanley D, Trowbridge EA, Norris SH. The mechanism of clavicular fracture. A clinical and biomechanical analysis. *J Bone Joint Surg Br* 1988;70:461–4.
- [26] Labronici PJ, Segall FS, Martins BA, et al. Clavicle fractures—incidence of supraclavicular nerve injury. *Revista Brasileira Ortopedia* 2013; 48:317–21.