Protection of Supraclavicular Nerve in the Surgical Procedures of Clavicle Fracture Fixation

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Abstract

Background: The present study was to evaluate the clinical effectiveness of the protection of the supraclavicular nerve in the treatment of clavicle fracture using fracture reduction and percutaneous external locking plate fixation or open reduction and internal fixation (ORIF).

Methods: A total of 27 patients suffered clavicle fracture and underwent fracture reduction and external or internal fixation with reserved clavicular epithelial nerve in our department from January 2015 to January 2020 were retrospectively collected, including 19 males and 8 females with a mean age of 42 years (range 21 to 57 years). Among them, 17 patients were treated with the fracture reduction and percutaneous external locking plate fixation, while the other 10 patients were treated with ORIF. The sensory function of the affected shoulder area and the superior lateral thoracic area after surgery was collected and analyzed, as well as the satisfaction rate after the fixation was removed.

Results: All the 27 patients were successfully followed with a mean duration of 1.3 years (1 to 5.8 years). There were significant differences in sensory dysfunction in the shoulder area and superior lateral thoracic area, pricking in the operation area and neck and shoulder, tactile hyperalgesia, and local numbness between the two groups after surgery ($P < 0.05$). All the fractures achieved bone union. The satisfaction rate in the percutaneous external locking plate fixation group was higher than that in the ORIF group after the fixation was removed ($P < 0.05$).

Conclusions: Percutaneous external locking plate fixation with reservation of the supraclavicular nerve in the treatment of clavicle fractures can reduce the incidence of postoperative paresthesia in the affected shoulder and superior lateral thoracic area, and improve the satisfaction rate of the surgical effect.

Background

The clavicular epithelial nerve comes from the superficial branches of the anterior ramus of the cervical plexus, and generally there are 2 to 3 branches, which originate from the 3rd and 4th cervical nerves. It goes from the midpoint of the posterior edge of the sternocleidomastoid muscle shallowly out of the skin, runs on the deep surface of the platysma to near the clavicle, and penetrates subcutaneously. It is divided into three branches, namely medial, middle and lateral branch, and distributes in the shoulder area and the superior lateral thoracic area across the clavicle.

Clavicle fractures are prone to occur in the one-third of the medial lateral clavicle [1-7], which belongs to the area where the supraclavicular nerves are distributed. Clavicle fractures are mainly treated with ORIF, in which the supraclavicular nerve is easily damaged, and the incidence of paresthesia such as numbness and discomfort in the affected shoulder and superior lateral thoracic area after surgery is as high as about 30% [1,3,4,8-10]. Previous clinical studies have found that the main cause of paresthesia in the affected shoulder area and superior lateral thoracic area under ORIF is the injury to the supraclavicular nerve during the operation [2,5,11].

In the present study, 156 patients with clavicular fractures who underwent fracture reduction and fixation in our department from January 2015 to January 2020 were summarized, among which 27 patients were treated with open reduction fixation with reservation of the clavicular epithelial nerve. We tried to protect the supraclavicular nerves during open reduction and plate internal fixation of clavicular fractures to improve postoperative skin numbness.

Methods

In this study, a total of 27 patients suffered clavicle fracture and underwent fracture reduction and external or internal fixation with reserved clavicular epithelial nerve in our department from January 2015 to January 2020 were retrospectively collected, including 19 males and 8 females with a mean age of 42 years (range 21 to 57 years). All patients suffered from unilateral closed clavicle fracture, and the time from fracture to operation was less than 2 weeks, without other parts combined fractures, old and pathological fractures, combined acromioclavicular joint and sternoclavicular joint dislocation, and mental retardation. The types of clavicle fractures in patients included 5 cases of transverse fracture, 8 cases of oblique fracture, and 14 cases of comminuted fracture. According to the different treatment methods used for fracture reduction during the operation, the patients were divided into two groups: the fracture reduction and percutaneous external locking plate fixation group and the ORIF group. Among them, 17 patients (15 males, 2 females) received fracture reduction and percutaneous external locking plate fixation, including 2 cases of transverse fractures, 5 cases of oblique fractures, and 10 cases of comminuted fractures; while 10 patients (4 males, 6 females) underwent ORIF, including 3 cases of transverse fractures, 3 cases of oblique fractures, and 4 cases of comminuted fractures.

Surgical technique

Treatment of patients in the fracture reduction and percutaneous external locking plate fixation group

The surgical procedure was as follows: ① Patient underwent general anesthesia or brachial plexus block anesthesia. After the anesthesia is stable, color Doppler ultrasound was used to locate the supraclavicular nerve and mark the surface of the skin (as shown in Figure 1) at the same time, with the patient in a supine position and tilt the head to the healthy side. ② Perform a conventional disinfection drape. ③ Make a 2~3cm surgical incision centering on the fracture of the clavicle, cut the skin and separate the subcutaneous tissue, then perform blunt dissection in the subcutaneous fat layer carefully with vascular forceps to reach the deep fascia layer of the platysma muscle; probe and protect the branch of the supraclavicular nerve that perpendicular to the clavicle on the surface of the clavicle; the clavicular epithelial nerves are moderately dissociated and protected, and should not be excessively stretched. ④ Reduce the fracture, place the clavicle locking plate 1~1.5 cm away from the skin, and fix both ends of the fracture with two locking screws, the length of which is generally about 26 mm.

Because the branches of the clavicular epithelial nerve were localized and marked by ultrasound preoperatively, the clavicular epithelial nerve branches that are not in the incision could be avoided during percutaneous screw fixation to avoid damage to the clavicular epithelial nerve branches. After the operation, a forearm sling was used to protect the affected upper limb for 3 weeks, and antibiotics were routinely used for 1~3 days after the surgery.

Treatment of patients in the ORIF group

The surgical procedure was as follows: ① Patient underwent general anesthesia or brachial plexus block anesthesia. After the anesthesia is stable, color Doppler ultrasound was used to locate the supraclavicular nerve and mark the surface of the skin (as shown in Figure 2) at the same time, with the patient in a supine position and tilt the head to the healthy side. ② Perform a conventional disinfection drape. ③ Make 8~10cm surgical incision centering on the fracture of the clavicle, cut the skin and separate the subcutaneous tissue, then perform blunt dissection in the subcutaneous fat layer carefully with vascular forceps to reach the deep fascia layer of the platysma muscle according to the preoperative ultrasound position mark, and 2 or 3 branches of the supraclavicular nerve can be found on the surface of the clavicle that almost perpendicular to the clavicle; reserve a small amount of fatty soft tissue around the supraclavicular nerve to avoid excessive nakedness of the supraclavicular nerve; separate the platysma muscle to release and protect the epithelial nerve depending on the circumstances, and the clavicular epithelial nerves should not be excessively stretched. ④ Strip part of the periosteum and reveal broken end of the clavicle fracture, then reduce the broken end of the fracture under direct vision, with care to protect the blood supply of the fracture end during this process. For patients with comminuted clavicle fractures, the bone fragments could be restored and fixed with Kirschner pins first, and then the broken ends of the fractures was reduced. After avoiding the supraclavicular nerve, an anatomical plate was placed on the surface of the clavicle, and the fractured end was internally fixed with screws. ⑤ Flush the field, suture the incision, and use a forearm sling to protect the affected upper limb for 3 weeks after the operation. Antibiotics were routinely used for 1~3 days after the surgery. Special attention should be taken not suture or ligate the clavicular epithelial nerve in the line knot when suturing the surgical incision, with indwelling skin for drainage. Postoperative antibiotics were routinely used for 1 ~ 3 days.

Results

All the 27 patients were successfully followed with a mean duration of 1.3 years (1 to 5.8 years). There were significant differences in sensory dysfunction in the shoulder area and superior lateral thoracic area, pricking in the operation area and neck and shoulder, tactile hyperalgesia, and local numbness between the two groups after surgery ($P<0.05$). All the fractures achieved bone union. The satisfaction rate in the percutaneous external locking plate fixation group was higher than that in the ORIF group after the fixation was removed ($P<0.05$) (Table 1).

Table 1

The incidence of paresthesia in the shoulder area and the superior lateral thoracic area of the affected side and the satisfaction rate of the surgical effect in the two groups after the removal of the fixed plate (%)

Group	Cases	Incidence of paresthesia in the affected shoulder area and the superior lateral thoracic area after removing the fixed plate	Satisfaction rate of the surgical effect
Percutaneous external locking plate fixation	17	0	82.35
ORIF	10	30%	80%
<i>p</i> value		0.04	0.02

There were 17 cases in the group of fracture reduction and percutaneous external locking plate fixation, 2 of which developed postoperative redness and swelling around the external screw, which were cured after anti-inflammatory and symptomatic dressing change. Before the healing and removal of the clavicle fracture, skin care such as regular symptomatic dressing change should be carried out for 4-5 days around the external screw, and normal saline cotton balls are generally used for cleaning and nursing. After the operation, 2 patients developed hyposensitization of the skin on the shoulder and upper chest area, which was completely recovered after oral intake of Methycobal Capsules and following up for 5-6 months. One patient developed redness and swelling around the external screw after the surgery (Figure 1d), which was cured after anti-inflammatory and symptomatic dressing change. It is necessary to pay attention to skin cleansing care such as symptomatic change of dressing around the external screw.

Among the 10 patients who underwent ORIF, 2 patients showed hypoesthesia of shoulder and upper thoracic skin after the operation, which returned to normal after 1 year of follow-up. Another 3 patients had injury to the supraclavicular nerve during the removal of internal fixation by incision one year after the surgery. These patients continued to follow up, and they had sensory dysfunction in the affected shoulder and superior lateral thoracic area, and tingling pain in the surgical area and neck and shoulders. Further follow-up of these patients revealed sensory dysfunction in the affected shoulder area and the superior lateral thoracic area, pricking in the operation area and neck and shoulder, tactile hyperalgesia, and local numbness.

Typical case

A 32-year-old male injured supraclavicular nerve during the second incision for removing the internal fixation, and suffered from night pain manifested as dull pain and prickling accompanied by itching. The pain radiated to the head, neck or shoulders and back, accompanied by neck stiffness and spasm and paralysis of the muscles under its control, followed by other symptoms such as anxiety, and hyperesthesia or hypoesthesia may appear in the nerve distribution area. After continuous follow-up

(outpatient follow-up every 3-6 months), the patient gradually improved significantly after the follow-up to about 3 years and 8 months. Five years after surgery: normal sleeping, no pain in the neck and shoulder area, the area of sensory dysfunction in the affected shoulder area and the superior lateral thoracic area returned to normal, but there still had tenderness and dull pain (tenderness (+) at the 1/3 of the medial lateral of the clavicle, Tinel sign (+) at acromioclavicular joint). As can be seen from the figure, the area of hypoesthesia in the 1-year postoperative follow-up is 15.5cm x 13.5cm, while the area of hypoesthesia in the 5-year postoperative follow-up is 9cm x 5cm. (Figure 3).

Discussion

Mechanism of clavicle epithelium injury

The supraclavicular nerves come from the superficial branch of the anterior branch of the cervical plexus. The nerve originating from the C3 and C4 nerves is the cutaneous nerve, which exists from the anterior of scalenus medius at 1/2 of the posterior margin of the sternocleidomastoid muscle and is immediately divided into three branches, namely the medial, middle, and lateral branches. Then it enters the posterior cervical triangle and lies between the deep and superficial fascia, and pass through the superficial layer of cervical fascia and the lower part of the platysma muscle in turn, and crosses distally over the front of the clavicle, dominating the sense of shoulders, upper chest, and lower neck. The most predisposed site of clavicle fractures is distributed at the 1/3 of the medial lateral of the clavicle [8,10,12-14], and it is relatively easy to damage the clavicular epithelial nerve during fracture or open reduction and internal fixation [3,4,6,11]. In the past, orthopaedic trauma physician often ignored the protection of supraclavicular nerves. Clavicular epithelial nerve injury leads to partial or complete loss of skin sensory function in the corresponding areas under its control such as the shoulder and upper chest, and increases the incidence of traumatic or scar neuroma, which causes "electric shock-like" prickling and affects sleep at night.

Although the skin paraesthesia of the affected side appeared after surgery, which did not affect the motor function of the upper limbs, the patient complained of numbness, prickling, itching, burning sensation and other discomfort in the affected shoulder area and superior lateral thoracic area after surgery. The main manifestations were discomfort such as neck and shoulder pain and soreness [3,4,15]:

- ☐ Pain: Acute attack, which can be dull pain, swelling pain, or prickling that can radiate to the head and neck or shoulder-back.
- ☐ Restriction of movement: Restriction of movement of the neck, accompanied by neck stiffness and spasm and paralysis of the muscles under its control.
- ☐ Paresthesia: Hyperesthesia or hypoesthesia may occur in the nerve distribution area, which affects the daily life of the patient, thereby reducing the patient's quality of life and satisfaction with the surgical effect. Therefore, iatrogenic clavicular epithelial nerve injury should be reduced in the fixation surgery for clavicle fractures, so as to reduce postoperative paresthesia in patients with clavicle fracture and improve patient satisfaction.

Advantages and disadvantages of clavicle fracture reduction and percutaneous external locking plate fixation

It has been reported that minimally invasive surgery for patients with clavicle fractures can reduce the surgical incision of the skin and improve the postoperative aesthetics of the surgical incision, but it cannot avoid the injury of supraclavicular nerve during the operation [15-19]. O'Neill et al. [20] reported that longitudinal skin incisions were placed with clavicle hook plates to avoid clavicular epithelial nerve injury. In 10 cases with ORIF, although the supraclavicular nerve was effectively protected during the first phase of the operation, it could still exhibit symptoms of nerve irritation due to the friction stimulation between steel plate and supraclavicular nerve as a result of the supraclavicular nerve against the surface of the internal fixation plate after the operation. In this group, three of the patients suffered iatrogenic clavicular epithelial nerve injury at the time of incision for the removal of internal fixation 1 year after surgery, and sensory dysfunction in the affected shoulder and superior lateral thoracic areas occurred. In 17 cases with fracture reduction and percutaneous external locking plate fixation, the incidence of paresthesia in the affected shoulder and superior lateral thoracic area was low within 1 year after the operation, and 2 of the patients developed hypoesthesia in the skin of the shoulder and upper chest after the operation, which returned to normal after 1 year of follow-up. The advantages of percutaneous external locking plate fixation surgery are that it effectively reduces the possibility of injury to the supraclavicular nerve in the first-stage of internal fixation and the second-stage of removal of internal fixation [20-23]. However, there are also shortcomings: Postoperative redness and swelling around the external screw occurred in 2 cases, which were cured after anti-inflammatory and symptomatic dressing change. Long-term skin care, such as symptomatic dressing change, is needed around the external screw, which affects the appearance to some extent after the operation, leading to psychological repulsion in a small number of patients, which requires patient guidance and explanation by medical staff and close follow-up to guide their recovery process.

Through reviewing the treatment of clavicle fractures in this paper, the authors concluded as follows: ☐ Percutaneous external locking plate fixation can effectively avoid further damage to the local blood supply of the fracture, and external elastic fixation stimulates callus regeneration and promotes fracture healing. ☐ Percutaneous external locking plate fixation can effectively reduce the possibility of clavicular epithelial nerve injury by using small longitudinal incisions with nail holes combined with the protection from the guide. ☐ Percutaneous external locking plate fixation effectively reduced the nerve stimulation caused by the friction between the plate and the supraclavicular nerve after the open reduction and fixation of the clavicle fracture in the first-stage. ☐ Particularly, there is no need to hospitalize and re-operation to cut the skin in the second phase of the removal of internal fixation, reducing the pain of the second operation and the patient's medical expenditure, and more importantly, avoiding the possibility of abnormal skin sensory function in the shoulder and upper chest due to the supraclavicular nerve injury caused during the removal of internal fixation.

Conclusion

Open reduction and internal fixation with reservation of the supraclavicular nerve in the treatment of clavicle fractures can reduce the incidence of postoperative paresthesia in the affected shoulder and superior lateral thoracic area, and improve the satisfaction rate of the surgical effect.

Abbreviations

ORIF: open reduction and internal fixation

Declarations

Ethics approval and consent to participate

All methods in this study were carried out in accordance with the Declaration of Helsinki. This study was approved by the Ethics Committee of The First Affiliated Hospital of Xinjiang Medical University. Written informed consent was obtained from all patients for their data to be recorded in our study.

Consent for publication

Informed consent was obtained from all patients for their data to be published in our study.

Availability of data and materials

The datasets generated and analysed during the current study are not publicly available due to limitations of ethical approval involving the patient data and anonymity but are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' Contributions

AA: Conducted the study. Collected, analyzed and interpreted the data. Wrote the manuscript.

YSL: Collected, interpreted and analyzed the data. Edited the manuscript.

KL: Created and statistical analyzed the data. Edited the manuscript.

FYC: Provided software assistance. Edited the manuscript.

AA: Conducted the study and provided the data.

XM: Conducted the study and provided the data.

PR: Conducted the study and provided the data.

AY: Planned the project. Reviewed the manuscript.

Abulaiti Abula and Yanshi Liu contributed equally to this study.

All authors read and approved the final manuscript.

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Figures

Figure 1

a Color doppler ultrasound was used to locate the supraclavicular nerve and mark the surface of the skin. b Surgical marks on the skin. c The radiograph of clavicle after external plate implantation. d Appearance photo of shoulder after external plate implantation.

A

B

C

D

Figure 2

a Surgical mark on the skin. b Color Doppler ultrasound was used to locate the supraclavicular nerve and mark the surface of the skin. c Appearance photo of shoulder after external plate implantation. d The radiograph of clavicle after external plate implantation.

A

B

Figure 3

A 32-year-old male injured supraclavicular nerve during the second incision for removing the internal fixation, and suffered from night pain manifested as dull pain and prickling accompanied by itching. a, b The hyperesthesia or hypoesthesia area