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ORIGINAL ARTICLE

Supraclavicular Nerves: Is There a "Safe Zone" for Surgical Fixation of the Clavicle? A Cadaveric Study

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Abstract

Objective: The supraclavicular nerve (SCN) supplies the skin over the clavicle and proximal chest. The unpredictable branching pattern of the SCN within the posterior triangle of the neck makes it susceptible to damage during open fixation of clavicle fractures. Resultant iatrogenic injuries can lead to paraesthesia and neuroma formation in the vicinity of the clavicle. The position of the SCN branches in relation to clinically appreciable landmarks has not hitherto been described. The aim of this study was to identify the precise location of the SCN branches in relation to the acromioclavicular (AC) and sternoclavicular (SC) joints.

Methods: Ten soft-embalmed cadavers, donated under the Human Tissue Act (2004), were carefully dissected along the superior border of both clavicles to identify the SCN branches. The distance from each branch of the SCN to the SC and AC joints was measured.

Results: The SCN was found to comprise either 2 branches (8/20), or 3 branches (12/20). No branches were found within 2.6 cm and 2.9 cm of the SC and AC joint, respectively. Between these two "safe zones", the locations of the branches varied significantly.

Conclusion: No safe zone was identified in the mid-clavicular region. Hence, meticulous dissection is required here to preserve the SCN branches.

Key Words: *Clavicular fracture; Supraclavicular nerves; Iatrogenic damage; Safe zones; Cadaver study*

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Introduction

The supraclavicular nerve (SCN) is a cutaneous branch of the cervical plexus that supplies the skin over the clavicle, upper chest, and the anterior shoulder [1]. The SCN emerges at the midpoint of the posterior border of the sternocleidomastoid (SCM) muscle, together with other superficial branches of the cervical plexus, at Erb's point. It then descends deep to the investing fascia and platysma in the posterior triangle of the neck, towards the clavicle.

Within the posterior triangle, the SCN typically divides into three branches, the medial, intermediate, and lateral branch. These branches pierce the investing fascia and the platysma, and course over the clavicle to supply the skin. The medial branch travels down to the sternoclavicular (SC) joint to supply the skin over the manubriosternal joint; the intermediate branch courses anterior to the clavicle and innervates the skin down to the level of the 2nd rib, and the lateral branch runs towards the acromion of the scapula and supplies the skin over the proximal half of the deltoid.

Fractures of the clavicle are very common and account for between 4 and 10% of all fractures in adults [2] and 44% of all fractures of the shoulder girdle [3]. These fractures most commonly occur in the middle third of the clavicle (over 80% of cases) [2]. Fractures of the lateral third account for between 21% and 28%, and fractures of the medial third between 2% and 3% [4]. The incidence of clavicular shaft fractures in males is highest under thirty years of age, and then decreases with age. In females, there is a bimodal distribution which peaks in the teenagers, and again in the elderly [5].

Due to the proximity of the supraclavicular nerve branches to the clavicle, there is a risk of damage following fractures, and in surgical fixation for these injuries. In practice, SCN injury is rarely observed as a direct consequence of traumatic clavicular fractures but occurs more often as a result of operative intervention for the fracture [6].

Most clavicle fractures are treated conservatively and are considered to have a low non-union rate [7]. More recent studies, however, have shown that non-union rates over the last 20 years are higher than previously thought, at around 7.5% [8]. This has led to a change in approach, with operative management now recommended for athletes and young, active patients [2], as well as in cases of displaced fractures, which have a high non-union rate [9]. Other risks with conservative treatment include functional impairment of the shoulder and a non-aesthetic lump at the base of the neck due to callus formation and shortening of the clavicle [10].

Although the conservative approach remains the treatment of choice for simple un-displaced clavicle shaft fracture, surgical intervention has increasingly been used to treat displaced fractures as it shows better outcomes and early functional recovery in young active adults [11]. The surgical approach, however, carries a risk of transecting one or more branches of SCN, which leads to paraesthesia of the proximal anterior chest in almost one-third of cases [6]. If the precise location of the terminal branches of the SCN was well understood the risk of intraoperative damage would be reduced.

Previous studies have shown considerable variation in the branches of the SCN. Nathe et al. [12] found that the intermediate branch was present in only 49% of 37 shoulder specimens and identified two safe zones (in which no branches of the supraclavicular nerve were identified) within 2.7 cm of the SC joint and 1.9 cm of the acromioclavicular (AC) joint. However, the study did not include any demographic

information on the donors. In Havet et al.'s [13] study the intermediate and lateral branches of the SCN in 14 neck dissections, and found the intermediate branch was present in all cases. However, the medial branch was not identified to confirm the presence of all three branches, limiting the usefulness of the study.

In this study, we aimed to identify the position of the branches of the SCN in relation to anatomical landmarks of the clavicle, and highlight its clinical significance, particularly in surgical fixation of the clavicle.

Materials and Methods

Bilateral dissections were carried out on 10 soft-fixed cadavers donated under the UK Human Tissue Act (2004). All cadavers were free from mechanical or traumatic injuries to the shoulder girdles and the thorax. Prior to dissection, the SC and AC joints were identified, and pins were inserted at their anterior border. The distance between the pins was measured and recorded as the clavicle length (Figure 1).

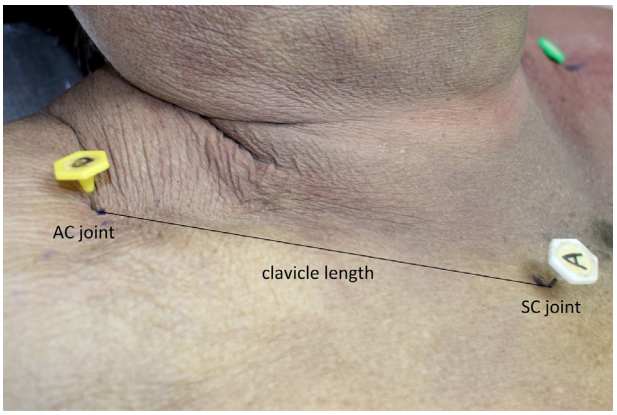

Figure 1) *Photograph showing the technique for measuring clavicle length.*

A transverse skin incision was made along the superior border of the clavicle from the SC joint to the AC joint. This incision was in line with a surgical approach used in open reduction and internal fixation (ORIF) of the clavicle [14]. Subsequently, meticulous dissection of the soft tissue was performed to identify the SCN branches as they coursed perpendicularly over the clavicle. The distances between each branch of the supraclavicular nerve to and the SC and AC joints were measured. All measurements were taken three times, and averaged values were used.

The data were divided into two groups based on the branching pattern of the SCN. Group 1 consisted of dissections in which two branches (the medial and lateral branches) were found (Figure 2). Group 2 included dissections in which three branches (the medial, intermediate, and lateral branches) were identified (Figure 3).

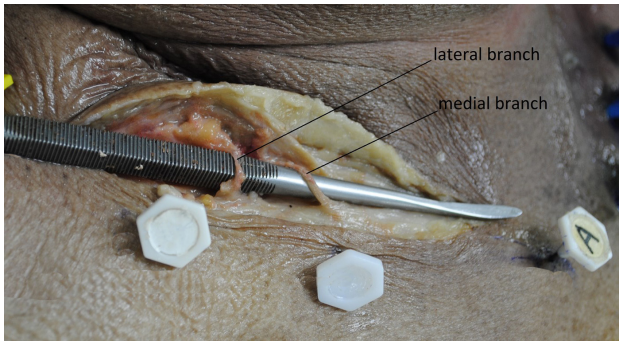

Figure 2) *Photograph of a Group 1 specimen showing the medial and lateral branches of the supraclavicular nerve.*

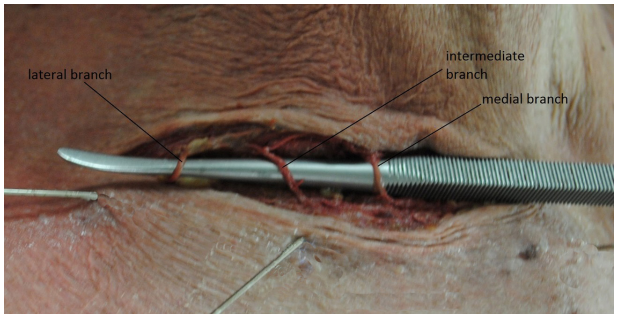

Figure 3) *Photograph of a Group 2 specimen showing the medial, intermediate, and lateral branches of the supraclavicular nerve.*

The average distance from these nerve branches to the AC and SC joints was measured. The 95% confidence interval (equivalent to 2 standard deviations) of the location of each branch in relation to the AC and SC joints was calculated, both as the absolute anatomical distance and as a percentage of the length of the clavicle.

Results

The cadavers used in this study were eight females and two males, with an average age of 81.2 years, ranging from 54 to 99 years.

The pattern of two branches (medial and lateral-Group 1) and three branches (medial, intermediate, and lateral-Group 2) was found in 40% (8/20) and 60% (12/20) sides, respectively. Two cadavers were found to have variation between right and left sides, with two branches (Group 1) on the left side, and three branches (Group 2) on the right side (Table 1). In both individuals, the left clavicle was shorter than the right (by 8 mm and 5 mm, respectively).

There was significant variability in the location of the nerve branches in relation to the bony anatomical landmarks (SC and AC joints) (Tables 2-5). A safe zone was identified where no medial branch was found within 2.6 cm of the SC joint, and no lateral branch was found within 2.9 cm of the AC joint (Table 4). Although the mean clavicle length in Group 1 was 10% shorter than that in Group 2, the difference was not significant ($p>0.05$).

TABLE 1

Characteristics of Group 1 (two branches) and Group 2 (three branches)

	Group 1(n=8)	Group 2 (n=12)
Age	76.0 ± 14.2	84.7 ± 8.3
Male	1	3
Female	7	9
Clavicle length, SD (mm)	129.21 ± 8.44	140.85 ± 8.73

TABLE 2

Absolute distance from each nerve branch to SC or AC joint in Group 1

	SC to MB (mm)	SC to LB (mm)	AC to MB (mm)	AC to LB (mm)
Mean	54.31	80.39	74.76	49.79
Two SDs	± 14.39	± 23.91	± 33.98	± 19.18
CI	39.92-68.70	56.48-104.30	40.78-108.74	30.61-68.97

SC: Sternoclavicular Joint; MB: Medial Branch; LB: Lateral Branch; AC: Acromioclavicular Joint; LB: Lateral Branch; SD: Standard Deviation; CI: 95% Confidence Interval

TABLE 3

Distance from each nerve branch to SC or AC joint as percentage of clavicle length in Group 1

	SC to MB (%)	SC to LB (%)	AC to MB (%)	AC to LB (%)
Mean	42.13	61.97	57.45	38.34
Two SDs	± 11.47	± 11.33	± 18.32	± 9.88
CI	30.66-53.60	50.64-73.30	39.13-75.77	28.46-48.22

SC: Sternoclavicular Joint; MB: Medial Branch; LB: Lateral Branch; AC: Acromioclavicular Joint; LB: Lateral Branch; SD: Standard Deviation; CI: 95% Confidence Interval

TABLE 4

Absolute distance from each nerve branch to SC or AC joint in Group 2; figures in bold text show the 'safe zone' in mm

	SC to MB (mm)	SC to IB (mm)	SC to LB (mm)	AC to MB (mm)	AC to IB (mm)	AC to LB (mm)
Mean	49.9	73.03	96.99	96.02	71.46	48.43
Two SDs	± 24.09	± 23.96	± 16.76	± 17.94	± 23.43	± 19.87
CI	**25.81**-73.99	49.07- 96.99	80.23- 113.75	78.08-113.96	48.03-94.89	**28.56**-68.3

SC: Sternoclavicular Joint; MB: Medial Branch; LB: Lateral Branch; AC: Acromioclavicular Joint; LB: Lateral Branch; SD: Standard Deviation; CI: 95% Confidence Interval

TABLE 5

Distance from each nerve branch to SC or AC joint as percentage in Group 2

	SC to MB (%)	SC to IB (%)	SC to LB (%)	AC to MB (%)	AC to IB (%)	AC to LB (%)
Mean	35.25	51.65	68.81	68.16	50.71	34.27
Two SDs	± 13.91	± 12.11	± 6.02	± 9.07	± 14.45	± 11.28
95% CI	21.34-49.16	39.54-63.76	59.09-77.23	36.26-77.23	36.26-65.16	22.99-45.55

SC: Sternoclavicular Joint; MB: Medial Branch; LB: Lateral Branch; AC: Acromioclavicular Joint; LB: Lateral Branch; SD: Standard Deviation; CI: 95% Confidence Interval

Discussion

Although the SCN is described in standard anatomy textbooks as having three branches, many variations have been reported. The precise location of the branches in relation to anatomical landmarks remains elusive. This study aimed to provide more detailed anatomical knowledge of the SCN branches, in relation to clinically appreciable landmarks.

The two branching patterns, with either two (Group 1) or three branches (Group 2), identified in this study, supports the findings of Nathe et al. [12]. They also reported that there was no significant difference in mean clavicle length between the two groups. Although we found the mean clavicle length of Group 1 was 10% shorter than Group 2, the difference in length was not statistically significant, which suggests that clavicle length is not related to the number of SCN branches.

We also found that the intermediate branch was present in only 60% of the sample and was located within the middle third of the clavicle. The presence of the intermediate branch can be unilateral (in two cadavers) or bilateral (in three cadavers). We also found that the intermediate branch (when present) coursed superficial to the clavicle in all cases. However, there have been several case reports of the intermediate branch tunneling through the clavicle [15-17].

I. Identification of "safe zones"

The aim of this study was to identify relevant surgical safe zones where no SCN branches were present, to avoid iatrogenic nerve injury. Two safe zones were identified, within 2.6 cm of the SC joint, and 2.9 cm of the AC joint.

However, 82% of fractures occur in the middle-third of the clavicle, in between these safe zones [18]. Therefore, in order to avoid nerve damage during surgical repair of the clavicle, only meticulous dissection and careful exposure of the nerve branches will avoid intraoperative damage. This approach has been shown to be effective in reducing skin numbness in patients with midclavicular fractures [19].

II. Limitations

Some limitations of this study should be considered. The sample size was limited to ten cadavers, two males and eight females. A larger number of cadavers with equal number of male and females is recommended for future studies, as this will give more representative results. In addition, the mean age of the cadavers was 81, which is not representative of the young population who are most likely to sustain a fracture of the clavicle.

Conclusion

Although 'safe zones' were identified at the extremities of the clavicle, no 'safe zone' was identified in the mid-clavicle region. Hence, meticulous dissection is required here during ORIF of clavicular fractures to preserve the SCN branches.

Acknowledgment

The authors sincerely thank those who donated their bodies to science so that this anatomical research could be performed. Results from such research can potentially increase mankind's overall knowledge and can then improve patient care. Therefore, these donors and their families deserve our highest gratitude [20].

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