



The dominant nutrient foramen at the clavicular midshaft: an anatomical study

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Abstract

Background The aim of the present study was to describe the prevalence and topography of the dominant nutrient foramen at the clavicle.

Methods 317 macerated human clavicles (167 right and 150 left) were available for the study. After detecting the dominant nutrient foramen, the total distance from the sternal surface to the examined nutrient foramen was measured. A foramen index (FI) was used for further data processing.

Results We detected a dominant foramen in 300/317 (94.64%) clavicles, which was located in the middle third in 287/300 (95.7%) clavicles. The average clavicular length was measured at 14.9 cm ± 1.0 cm (range 11.6–17.5 cm) with an average foraminal distance from the sternoclavicular joint surface of 7.9 cm ± 1.3 cm (range 0.9–12.6 cm) in total. The mean FI was 53.2% ± SD 7.4% (range 5.5–79.3%).

Conclusion The present study provides a topographic mapping of the foraminal area (46–60% of the total clavicular length). The findings help to assess clavicular fracture patterns, which pass through the foraminal area.

Keywords Clavicula · Fracture · Nutrient foramen · Blood supply · Complication · Fracture pattern · Non-union · Mal-union

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Introduction

Several previous investigations of the upper and lower limb demonstrated the importance of an anatomical understanding of the nutrient foramen with regards to surgical and trauma related outcome [6, 10–13].

The role of a dominant nutrient foramen at the clavicle still leads to controversial discussions. Some authors suggested that the foramen serves as an entry point for an essential nutrient artery—mainly a branch of the suprascapular artery—which supplies the middle third region of the clavicle, while other studies described that the dominant foramen carries the medial fascicle of the supraclavicular nerve [1, 5, 7]. Moreover, reports of its location and the prevalence differ. Radiological and anatomical studies reported that a dominant foramen are mostly present in the middle one-third of the clavicle with a prevalence of 6–96% [2, 9]. As fractures involving the midshaft account for 3/4 of all clavicle fractures, additional information about the topographical anatomy and morphology of the dominant nutrient foramen at the clavicle is of interest in various cases.

Therefore, the aim of the present study was to describe the topography and prevalence of the dominant nutrient foramen to detect fracture patterns that pass through the foraminal area.

Methods

In the present study, we used 317 embalmed human clavicles. These were composed of 167 right and 150 left specimens out of a total of 247 body donors (131 female, 116 male) with an average age of 55 years (range 18–86 years). All of them were prepared by maceration including the removal of soft tissue, disarticulation and the process of degreasing the bone by hydrogen peroxide. Subsequently to macroscopic examination we identified the dominant nutrient foramen by use of a testing probe and a magnifying lens (Fig. 1). The total length from the middle of the articular medial and lateral surfaces and the distance from the sternal end to the examined foramen were measured by means of a measuring stick (Fig. 2). Subsequently, we used a foramen index (FI) for further data processing. The index divides the measured distance of the dominant foramen by the total length of the clavicle and is then multiplied by 100. In addition we assigned the locations of the foramina to 1/3 regions of the bones in the medial (sternal) third, the middle third, and the lateral (acromial) third. The mean, minimum, and maximum values as well as the standard deviation were calculated. The study was approved by the institutional research board at the principal investigator's hospital.



Fig. 1 Posteroinferior view of the right clavicle with depiction of the dominant nutrient foramen at the posteroinferior aspect of the clavicle (black arrow)



Fig. 2 Anteroinferior view of a right clavicle. Measurement of the distance from the articular sternal surface to the examined dominant nutrient foramen (black arrow) by using a measuring stick

Results

We detected a dominant foramen in 300 (94.6%) of the 317 clavicles, while it was absent in 17 (5.4%) of the examined specimens. In one of the 317 clavicles the foramen was placed in the medial third region (0.3%), however, in most cases it was located in the middle third region 287 (95.7%) and 12 clavicles showed a lateral third formation (4%).

In total, we found an average clavicular length of $14.9 \text{ cm} \pm 1.0 \text{ cm}$ (range 11.6–17.5 cm) with an average foraminal distance from the sternoclavicular joint surface of $7.9 \text{ cm} \pm 1.3 \text{ cm}$ (range 0.9–12.6 cm).

The male average FI was $52.9\% \pm 8.71\%$ (range 5.5–77.3%) with a distance from the sternal end of $8.2 \text{ cm} \pm 1.5 \text{ cm}$ (range 0.9–12.0 cm). In females, we observed a mean FI of $53.6\% \pm 7.2\%$ (range 35.9–75.0%) showing a distance of $7.6 \text{ cm} \pm 1.1 \text{ cm}$ (range 5.1–10.5 cm). Left clavicles showed a length of $14.9 \text{ cm} \pm 1.1 \text{ cm}$ (range 11.6–17.5 cm) with an average FI of $53.4\% \pm 8.0\%$ (range 5.5–78.8%) compared to a length of $14.8 \text{ cm} \pm 1.0 \text{ cm}$ (range 12.3–16.9 cm) on the right side with a FI of $53\% \pm 7.4\%$ (range 35.9–79.3%). The mean FI was $53.2\% \pm \text{SD } 7.4\%$ (range 5.5–79.3%) overall.

Discussion

The present study describes the topography and morphology of the dominant nutrient foramen in a large series of 317 clavicles. A dominant foramen was measured with an average distance from the sternoclavicular joint surface of 7.9 cm (± 1.3 cm; FI $53.2\% \pm 7.7\%$) in 300 specimens with an average clavicular length of 14.9 cm. This observation

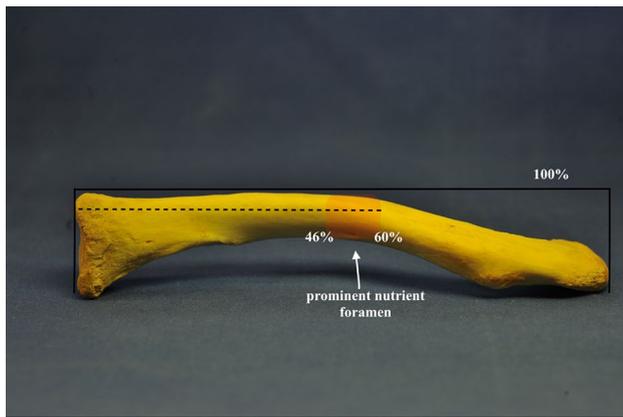


Fig. 3 Posterior view of the right clavicle. Presentation of the defined risk area (red) involving 46–60% (black dotted line) of the total clavicular length (black line)

complements previous studies, which reported differences in the prevalence of a dominant foramen at the clavicle [2, 9]. In the evaluated specimens we found a dominant foramen in nearly all specimens (95.7%).

In the clinical setting our findings may allow to better assess clavicular fracture patterns passing through the foraminal area. Based on the presented results a risk area between 46 and 60% of the total clavicular length could be defined (Fig. 3). This areal corresponds to the subclavian groove, which serves as attachment point of the subclavius muscle at the inferior part of the clavicle.

The clinical relevance of the study is supported by several previous investigations of the upper and lower limb, which demonstrated the importance of an anatomical understanding of the nutrient foramina for surgical and trauma related outcome [6, 10–13]. The role of a dominant nutrient foramen at the clavicle remains controversially discussed, especially due to its importance for clavicular blood supply. Previous authors reported that the clavicle is supplied by periosteal rather than nutrient arteries, which led them to conclude that the foramen is predominantly important for venous drainage [6, 7]. Contrary to that several other authors have stated that the periosteal vascular network of the clavicle is supplied by a nutrient artery, which runs through a dominant nutrient foramen [1, 5, 8]. These reports are supported by studies, which discussed the role of a dominant foramen in the context of the development of the clavicle. Even though the clavicle initially undergoes an intra-membranous ossification and displays a medial and lateral ossification center, these centers fuse in week 7 of gestation and are subsequently followed by a longitudinal enchondral growth of the clavicle with a progression of ossification from the center to periphery [3, 4]. This ossification is similar to that of axial long bones in which the major blood supply occurs through nutrient arteries [3, 4]. This would explain for the necessity of

central nutrient arteries at a central ossification point. This point is further solidified by our findings as the majority of the foramen were found in the middle third (FI 53%) of the clavicle.

It follows that certain fracture patterns of the clavicular midshaft or iatrogenic injuries in this area may result in a decrease of blood flow towards the clavicle, which may predispose to osteonecrosis as a paucity of nutrients creates a suboptimal environment for osteogenesis and repair.

A limitation of the current study can be found in the use of macerated specimens as the foramen were used as morphological surrogate structures. The results have to be discussed under this drawback.

However, the presented study provides information about the topographical anatomy and prevalence of the dominant nutrient foramen at the clavicle in a large cadaveric series. The findings have to be further elaborated in the clinical setting.

Compliance with ethical standards

Conflict of interest The authors, their immediate family, and any research foundation with which they are affiliated did not receive any financial payments or other benefits from any commercial entity related to the subject of this article.

Ethical approval The Ethics Commission of the Faculty of Medicine of Cologne University has approved the study.

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