Circumflex arterial sulcus of the scapula (sulcus arteriae circumflexae scapulae). Its anatomy and clinical relevance

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Research Article

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Abstract

Introduction: The circumflex scapular artery (CSA) has been described in detail in the literature, but the groove, i.e., the circumflex sulcus (CFS), formed by the artery on the lateral pillar of the scapula has been completely neglected. The aim of the present study was to describe the variability and anatomy of the CFS.

Material and method: The study was based on the examination of 103 pairs of dry bone specimens of adult scapulae, i.e., 206 specimens, including 92 (46 pairs) male and 114 (57 pairs) female specimens. In the first step, quantitative criteria were defined for assessment of the CFS presence and type. Subsequently, statistical analysis of the obtained data was performed.

Results: The study revealed considerable variability of the arterial groove, which was well-developed in 33% (type A), shallow in 40% (type B), and absent in 27% (type C) of cases. The mean distance between CFS and the infraglenoid tubercle was 3.3 cm (range, 2.5–5.4), which corresponds to the proximal third of the lateral border of the scapula.

Conclusion: The study has confirmed variability of the arterial groove (CFS) and its localization in relation to the inferior glenoid rim. The findings are clinically important, particularly in relation to the Judet approach to scapular fractures.

Introduction

Anatomy of the scapula has been at the forefront for quite a long time [1, 2, 8–13, 15, 16, 19–23, 28, 29, 31, 32, 34, 36], particularly due to the growing interest in operative treatment of scapular fractures and shoulder arthroplasty. These studies have provided a number of new metric details of the scapula and have defined new structures [2, 5, 6, 29, 33]. One of the studied structures is the circumflex scapular artery (CSA). This artery arises from the subscapular artery, curves backwards around the lateral border of the scapula and passes to its posterior surface where it anastomoses with the suprascapular artery. It leaves its imprint on the lateral border, namely the sulcus of the circumflex scapular artery [14, 17, 26, 30, 35], in short the circumflex sulcus (CFS) [4].

Knowledge of the CSA course in relation to the glenoid rim is essential for dissection of the interval between the teres minor and the infraspinatus in both the Judet and Dupont-Evrard approaches [4, 7, 11, 12], or for harvesting of a scapular osteocutaneous free flap[27].

The course of the CSA was described in detail by Ebraheim et al. [12] and Shin et al. [27], although with partially differing results. However, neither of these studies mentioned CFS, even if details about the sulcus could specify the course of CSA in relation to the inferior glenoid rim. Therefore, we decided to conduct our own study.

Material And Method

Material

The initial group comprised 330 scapulae. After exclusion of all unpaired scapulae and scapulae with pathological changes, the study group included 103 pairs, i.e., 206 dry bone specimens of adult scapulae found in Pachner´s collection of the Institute of Anatomy of 1st Faculty of Medicine of Charles University and Department of Anthropology and Human Genetics of the Faculty of Science of Charles University, Prague [25]. Sex and age were known in all the subjects.

A total of 206 paired specimens, i.e., 103 pairs, each pair always from the same individual, included 92 (46 pairs) male and 114 (57 pairs) female scapulae. The mean subject age of the whole group was 53 years: 52 years (range, 20–82) in men, and 53 years (range, 18–87) in women.

Method

The study focused on the CFS incidence, degree of its manifestation and the distance between CFS and the inferior glenoid rim.

CFS incidence: After the initial analysis, scapulae were divided into three groups: with (group A and B) and without CFS (group C). Scapulae with a more- or less-developed groove were examined for duplication of the sulcus, or its division into the superior and inferior branches.

Anatomy of the sulcus: As the first step, criteria for the determination of individual types of CFS were set, with the resulting two groups: A – a well-developed groove > 0.5 mm deep; B – a shallow groove > 0 mm and ≤ 0.5 mm in depth. The depth of the groove was measured on the posterolateral surface of the lateral pillar of the scapula, using a digital caliper.

Distance between CFS and the inferior glenoid rim

This distance was measured using a digital caliper, similarly the length of the lateral border of the scapula between the inferior glenoid rim and the apex of the inferior angle. Subsequently, standard deviation (σ) was calculated for the two measurements; and the ratio of the two distances was also determined and expressed as percentage.

Evaluation

In addition to the sulcus incidence, manifestation and position, side-to-side differences in each individual and differences between men and women were also examined. T test was used to compare CFS incidence between male and female scapulae. A paired test and Pearson correlation coefficient (r) were applied to compare CFS incidence between the right and left sides, separately in men and women. Pearson´s Chi-square test (p_{chi}) served to determine quantitative categories of CFS incidence between men and women.

Results

The basic data are shown in Table 1.

Table 1
Incidence of individual types of CFS

Type	**male (*n* of scapulas)**	**female (*n* of scapulas)**	**all (*n* of scapulas)**
A – well developed			
depth of the groove > 0,5 mm	33% (29)	34% (39)	33% (68)
B – shalow			
depth of the groove > 0 mm and ≤ 0,5 mm	45% (41)	37% (42)	40% (83)
C – absent			
depth = 0 mm	22% (22)	29% (33)	27% (55)
Total	92 scapulas	114 scapulas	206 scapulas

CFS incidence

CFS was absent (group/type C) in 55 (26.8%) specimens; 22 (10.7%) male and 33 (16.1%) female scapulae. CFS was more or less developed in 151 (73.2%) cases; 70 (33.9%) male and 81 (39.3%) female scapulae (Fig. 1).

CFS anatomy

A well-developed groove, i.e., a clearly visible CSA imprint on the lateral border of the scapula and its posterior surface, was classified as type A. It passed mediocranially to the nutrient foramen at the base of the scapular spine, close to the spinoglenoid notch. The groove was > 0.5 mm deep and could be well-seen and easily palpable (Fig. 1). Type A was found in 33% of all scapulae, more specifically in 33% of male and 34% of female scapulae. A duplicated sulcus was identified in 5, all of them female, specimens. A divided sulcus was recorded in 7 cases (2 male and 5 female scapulae).

A shallow groove, difficult to distinguish and palpate, was classified as type B, its course being similar to type A. Type B depth ranged between > 0 mm and ≤ 0.5 mm (Fig. 1). Type B occurred in 40% of all scapulae, more specifically in 45% of male and 37% female scapulae. A duplicated sulcus was identified in 4 male specimens. A divided sulcus was recorded in 3 cases (1 male and 2 female scapulae).

A divided sulcus was defined as a groove originating from one “trunk” on the lateral border and dividing subsequently on the posterior surface of the scapular body into the superior and inferior branches (Fig. 2). The superior branch travelled to the nutrient foramen in the area of the spinoglenoid notch, and the inferior branch to the inferior pole of the scapula. Such a situation was observed in 10 specimens. In 4 pairs, this finding was seen in both scapulae (1 male pair of type A, 2 female pairs of type A, 1 male pair of type B); in 2 pairs it was unilateral (1 male scapula of type B, 1 female scapula of type A). The imprint of the superior arterial branch was more distinct while that of the descending (muscular) branch was less clear in all cases.

A duplicated sulcus, i.e., two grooves on the posterior surface of the lateral scapular border (Fig. 2), was found in 9 cases (5 of type A and 4 of type B). Identical such findings on the left and right sides were observed in 3 pairs (6 scapulae): 1 pair of male and 2 pairs of female scapulae. In another 3 pairs the presence of a CFS was only unilateral, with type A occurring in female and type B in male scapulae.

Relationship of CFS to the nutrient foramen at the scapular spine base

This nutrient foramen was sought in all 206 specimens and was identified in only 167 (81%) cases. In all these 167 cases CFS extended to the foramen (Figs. 1 and 2).

CFS course in relation to the inferior glenoid rim: The mean distance was 3.3 cm (range, 2.5–5.4) (σ = 0.541): 3.6 cm (range, 2.7–5.4) (σ = 0.577) in men and 2.94 cm (range, 2.5–4.2) (σ = 0.324) in women.

The total length of the lateral border and the proportional distance between CFS and the lower glenoid rim: The mean total length of the lateral border measured between the infraglenoid tubercle and the apex of the inferior angle was 13.2 cm (range, 11.6–15.4) (σ = 0.76): 13.7 cm (range, 12.5–15.4) (σ = 0.73) in men and 1.8 cm (range, 11.6–13.8) (σ = 0.49) in women. The mean distance between CFS and the lower glenoid rim accounted for one quarter (24.1%) of the total length of the lateral border of the scapula. This value was slightly higher in men, i.e., 26.1% (range, 21.1–35.1%) than in women, i.e., 23.0% (range, 19.3–30.4%). No significant differences were found between the right and left sides in the same individual.

Statistical analysis

T test between the measured values of the distance of the arterial groove from the infraglenoid tubercle in men and women (T = 0.0018) did not show any significant statistical difference between sexes.

Evaluation of the incidence of the same sulcus type on the right and left sides in the same individual was based on the paired test (p) (for men p = 0.265244, for women p = 0.26694), and Pearson correlation coefficient (r) was used to determine whether the incidence of a given sulcus type is similar on the right and left sides in both sexes (for men r = 0.810649, for women r = 0.95295). The side-to-side incidence showed a high correlation rate.

The Pearson Chi-square test (p_{chi} = 0.0246) confirmed, with a 98% probability, that the distribution in A, B, C groups (types) between males and females was the same.

The scatter plots show distribution across A, B, C groups and the correlation between right and left sides (coefficient of reliability R^2; in men: R^2 = 0.9307; in women R^2 = 0.9184) (Figs. 3, 4).

Statistical analysis showed a high rate of correlation in the incidence of the same CFS type between sexes and between the right and left sides, similarly as in the existence of the same CFS type on the right and left sides in the same individual.

Discussion

The CFS has been mentioned very briefly in only a few osteology textbooks [14, 35]. Standard anatomy textbooks [17, 26, 30] do not describe it. The same applies to clinical studies dealing with CSA [12, 27].

The CFS develops as a CSA imprint, which has been confirmed by 3D CT reconstructions in scapular fractures (Fig. 5). The CSA is a branch of the subscapular artery, traversing the triangular space between the subscapularis above, the teres major below and the long head of the triceps laterally. The artery passes through the teres minor, then bisects and enters the infraspinous fossa over lateral border of the scapula. Here it divides into two branches (Fig. 6).

The proximal, ascending branch travels to the nutrient foramen at the scapular spina base and then to the spinoglenoid notch where it anastomoses with the suprascapular artery [12, 27]. During ossification, this nutrient foramen is located in the growth center [24] and its presence is almost constant [10, 20]. Our finding of 81% is comparable to that reported by Kalný [20], who recorded it in 82% of the group of 100 scapulae and to Donders´ finding [10] of 87% in a group of 30 specimens.

The variable distal, descending branch of CSA continues along the lateral border of the scapula between the teres major and minor, and dorsally to the inferior angle, where it anastomoses with an ascending branch of the deep brachial artery [12, 27].

Our data about the distance between the CFS and the lower glenoid rim, i.e., 3.3 cm, is similar to those presented by Ebraheim et al. [12] in his study of 16 specimens. These authors described a so-called “risk area”, located on average 2.9 cm (2.4–3.4 cm) distal to the lower glenoid rim. Shin el al. [27] examined 57 specimens and found this distance longer by 1 cm, i.e., 4.3 cm.

Exact knowledge of the CSA course over the lateral border of the scapula is essential for surgical practice. In the Judet, or Dupont-Evrard, approach, dissection in the interval between the infraspinatus and teres minor requires ligation of the artery and its veins (Fig. 7). This fact was pointed out for the first time by Idrac [18] as early as in 1935. Identification of the CSA is an important step in the harvesting of a scapular osteocutaneous free flap from the lateral border of the scapula [27].

The CFS is an area of a high concentration of fracture lines in scapular body or neck fractures (Fig. 8), as proved by Armitage et al. [3] and Bartoníček et al. [5, 6]. The study by Tuček et al. [32] has suggested that one of the reasons for concentration of fracture lines in the upper half of the lateral pillar of the scapula may be the fact that it is weaker in the area of the CFS.

Our study, the first of its type, has demonstrated a high symmetry in the incidence of the arterial groove between the right and left sides of different pairs of scapulae, as well as between the two sides in the same individual. As a result, the incidence and type of CFS is obviously not influenced either by the right/left dominance of the upper extremity or by the asymmetry of the muscle mass on the dominant and non-dominant extremity.

Conclusion

This study of 206 dry specimens of the scapula provided a basis for description of the incidence, variability and clinical importance of the CFS. This groove, formed by the imprint of the CSA's superior branch was found in 73% of cases. It was located, on average, 3.3 cm (range, 2.5–5.4) distal to the lower glenoid rim and had a typical course medially and proximally to the nutrient foramen at the scapular spina base, close to the spinoglenoid notch. Knowledge of CFS location is important for the Judet, or Dupont-Evrard, approach to scapular fractures and for harvesting of scapular osteocutaneous free flaps.

Declarations

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

Disclaimer: "None"

Ethics approval and consent to participate:This article does not contain any studies with human participants, or animals, performed by any of the authors.

Consent for publication 'Not applicable'

Availability of data and materials – data are obtained from institutional collections - Pachner´s collection of the Institute of Anatomy of 1st Faculty of Medicine of Charles University and Department of Anthropology and Human Genetics of the Faculty of Science of Charles University, Prague.

Competing interests'Not applicable'

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Authors' contributions:

TS: Data collection and analysis, manuscript writing

JB: Project development, manuscript editing

MT: Data analysis

ON: Data analysis, statistic analysis, manuscript editing

All authors reviewed the manuscript.

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Figures

Figure 1

Types of CFS. **a** – absent CFS (type C), **b** – shallow CFS (type B), **c** – well-developed CFS (type A).

The black arrow indicates the nutrient foramen, the red arrow shows the CFS, the yellow arrow indicates the appearance of CFS on the lateral border of the scapula.

Figure 2

CFS variability**. a** – divided CFS; **b** – duplicated CFS. The black arrow indicates the nutrient foramen, the red arrow shows the CFS on the posterior surface of the scapula, the yellow arrow indicates the appearance of the CFS at the lateral border of the scapula.

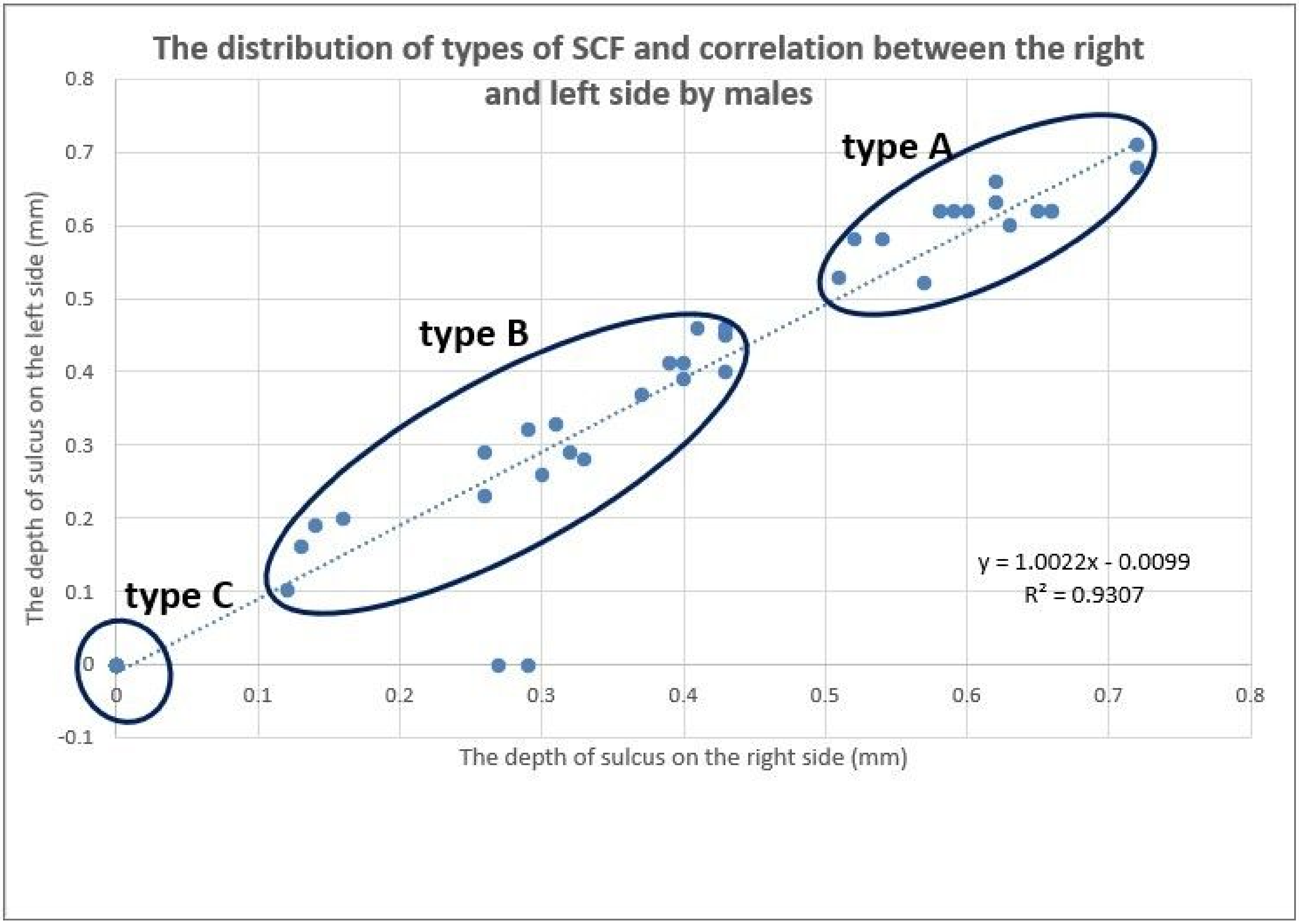

Figure 3

Scatter plot of distribution of the CFS between the right and left sides in males.

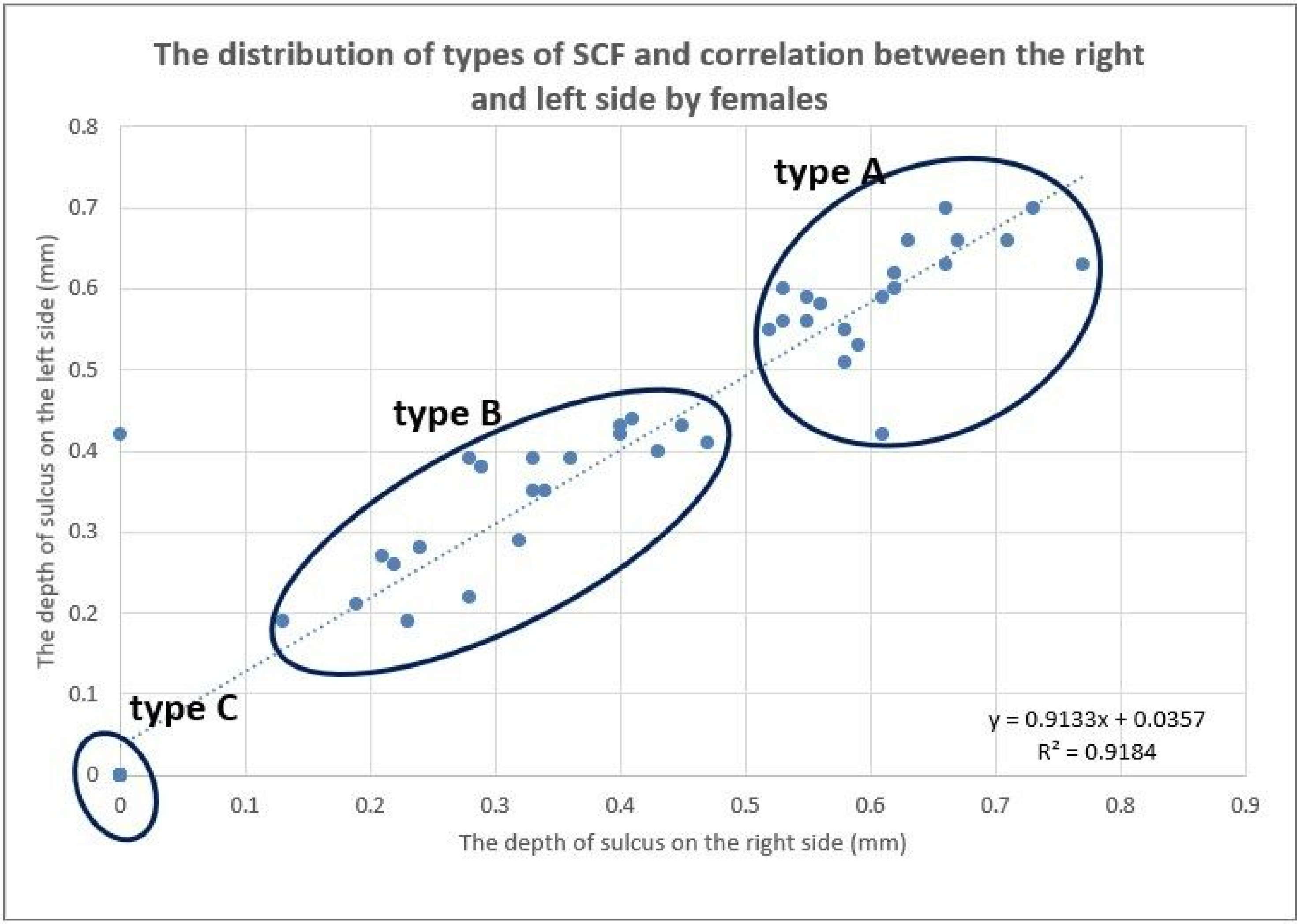

Figure 4

Scatter plot of distribution of the CFS between the right and left sides in females.

Figure 5

The course of the CSA on 3D CT reconstructions of the scapula. **a** – the course of the ascending branch (red arrow) of the CSA; **b** – division of the CSA into the ascending branch (red arrow) and descending (muscular) branch (yellow arrow).

Figure 6

Arteries in the area of the lateral border of the scapula on 3D CT reconstruction in anterior dislocation of the glenohumeral joint. 1 - subscapular artery; 2 - posterior circumflex humeral artery; 3 - thoracodorsal artery; 4 - circumflex scapular artery; 4a – ascending branch, 4b – descending muscular branch.

Figure 7

Passage of the CSA over the lateral border of the scapular body and its ligation in the Judet approach. IS –infraspinatus, CSA – circumflex scapular artery, LP – lateral pillar of the scapula, TMi –teres minor.

Figure 8

Concentration of fracture lines in the area of CFS in scapular fractures on 3D CT reconstructions. Red arrows indicate the course of the CSA **(a)** or the CFS **(b)**.