

# Morphology of ulnar trochlear notch and defining ideal position for olecranon osteotomy

## Morfología de la ulna muesca troclear y definición de la posición ideal para la osteotomía del olecranon

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### Abstract

**Objective:** The aim of the study was to calculate the most important parameters of ulna and to determine its gender. Classifying trochlear notch joint surface types and to establish their representation in Serbian population. To determine the ideal position for olecranon osteotomy. **Material and methods:** The study included 69 bones. Gender determination was performed using digital scale and photographs of the ulna. The bones weight, maximum and physiological length were measured. The place for the ideal position of olecranon osteotomy (projection of the bare area on its posterior wall) was determined on profile images. **Results:** Gender related, 45 (65.21%) bones belonged to males, 24 (34.79%) ulnas belonged to females. Type I of the bare area was present in 38 (55%) ulnas, type II in 20 (29%), whereas type III was present in 11 (16%) bones. The average value for the ideal position of olecranon osteotomy was 23.02 mm. In males' ulnas, it was 23.22 mm, in females, it was 22.59 mm. **Conclusion:** Type I of the bare area is the most common type of trochlear notch joint surface in Serbian population. The average value for the ideal position of olecranon osteotomy was 23.02 mm. We believe that a uniform name for the bare area should be established.

**Keywords:** Ulna. Olecranon process. Trochlear notch. Osteotomy. Gender.

### Resumen

**Objetivos:** Calcular los parámetros más importantes del cúbito y determinar su género. Clasificar los tipos de superficie de la articulación de la escotadura troclear y establecer su representación en la población serbia. Determinación de la posición ideal para la osteotomía del olécranon. **Material y métodos:** El estudio incluyó 69 huesos. La determinación del sexo se realizó mediante escala digital y fotografías del cúbito. Se midió el peso de los huesos, la longitud máxima y fisiológica. El lugar para la posición ideal de la osteotomía del olécranon se determinó en imágenes de perfil. **Resultados:** Relacionado con el género, 45 (65.21%) huesos pertenecían a hombres, 24 (34.79%) cúbitos pertenecían a mujeres. El tipo I del área descubierta estuvo presente en 38 (55%) ulna, el tipo II en 20 (29%), mientras que el tipo III estuvo presente en 11 (16%) huesos. El valor medio para la posición ideal de la osteotomía del olécranon fue de 23,02 mm. **Conclusión:** El área desnuda tipo I es el tipo más frecuente de superficie articular de muesca troclear en la población serbia. El valor promedio para la posición ideal de la osteotomía del olécranon fue de 23,02 mm. Creemos que se debe establecer un nombre uniforme para el área descubierta.

**Palabras clave:** Ulna. Proceso del olécranon. Escotadura troclear. Osteotomía. Género.

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## Introduction

Ulna is one of the bones of the forearm and it is positioned on the medial side of the radius and slightly behind it, in physiological position of supination. According to its shape, ulna belongs to long bones (*ossa longa*) and it is also an even bone. We distinguish the body and two end parts of the bone<sup>1</sup>. There are a trochlear notch, olecranon, and coronoid process on proximal end of ulna. Trochlear notch (*incisura trochlearis*) represents a concave joint surface and it is positioned between coronoid process and olecranon. Bare area divides it into two slopes corresponding to the joint surfaces which articulate with the trochlea of humerus. Olecranon is located at the upper back of the proximal part of the ulna. It tends to have a cube shape, on the front side being recessed into a smooth surface which forms part of the trochlear notch. The triceps attaches to the upper side of the olecranon and its posterior surface is rough and subcutaneous. Coronoid process represents front bottom eminence of the proximal part of ulna. Its shape resembles a four-sided pyramid. Upper side of coronoid process makes the bottom wall of the trochlear notch. On the lateral side, there is a radial notch (*incisura radialis*) which represents joint surface as well<sup>1</sup>.

Data about gender affiliation are very important in every anthropological research, although it is not a simple task to determine gender on a single bone<sup>2,3</sup>. There are several ways of determining gender affiliation of ulna in the literature. We assume that authors Reddy and Doshi described optimal parameters<sup>3</sup>.

Several classifications of trochlear notch are described regarding shapes of its joint surfaces. They indicate generally present anatomical variation, with certain degree of representation in different populations<sup>4,5</sup>.

As fractures of distal humerus are relatively common injuries of the upper extremity, from the clinical point, type of trochlear notch joint surface is significant for performing olecranon osteotomy during operative treatment of the mentioned fractures. Olecranon osteotomy with opened reposition and internal fixation represents widely accepted method of operative treatment for type C fractures of distal humerus (complete intraarticular fracture)<sup>5</sup>. Compared to other surgical approaches to distal humerus, it provides the best approach<sup>6</sup>, thus increasing the success of the surgical treatment. Furthermore, the authors suggest the possible impact of variations in trochlear notch joint surfaces on arthroscopic elbow surgeries, design



**Figure 1.** Intraoperative view of the chevron olecranon osteotomy (Photo from the personal archive of intraoperative photos of co-author Dr. Mirko Obradović).

of prostheses for performing elbow arthroplasty, as well as its impact on elbow radiological imaging<sup>5</sup>. Projection of the bare area on posterior wall of ulna represents, “entry point” for performing olecranon osteotomy itself<sup>5,7</sup> as it is well known that the potential joint surface cartilage damage would lead to arthrosis of the affected joint. Besides, current recommendation from AO Foundation for olecranon osteotomy is to perform the chevron osteotomy<sup>8</sup> (Fig. 1). Bare area projection on the back side of the ulna is of crucial importance for such a procedure. Clinical importance of bare area is not supported in current anatomical terminology<sup>9</sup>. In other words, there is no specific name for transverse ridge (bare area) although it significantly morphologically differs from the rest of the trochlear notch<sup>10</sup>.

We presume that examining different parameters on ulna, as well as types of trochlear notch joint surfaces regarding their shape will bring important data related to Serbian population. We also believe that the indicative recognition of the bare area projection on the ulnar back wall would contribute to significantly better results in surgical treatment, intraoperatively, as well

as postoperatively, resulting in easier recovery and better function of the elbow. Goals of our paper were first to calculate the most important parameters of ulna and to determine its gender, based on the results. Second, the goal was to classify trochlear notch joint surface types and to establish their representation in Serbian population. Third, it was to determine the ideal position for olecranon osteotomy.

## Materials and methods

The research was conducted at the Department of Anatomy, Faculty of Medicine, University of Novi Sad. It included 69 bones from the Osteological museum which were of an unknown age. The research exclusion criteria were bone damages and previous fractures. All bones were photographed by *Canon EOS2000D* camera, using a photo stand. During the process, they were on the same distance and under the same angle compared to the camera. Further, photo processing and parameters calculation were done using *ImageJ 1.53K* software. The same person performed both photographing and photo processing.

We classified types of trochlear notch joint surfaces into three types, through direct visualization by the two people, based on the research of Totlis et al.<sup>5</sup>.

- Type I – Completely divided olecranon and coronoid process joint surfaces.
- Type II – Connected olecranon and coronoid process joint surfaces with constriction.
- Type III – Connected olecranon and coronoid process joint surfaces without constriction<sup>5</sup> (Fig. 2).

The following parameters were measured to define ulna's gender affiliation, using a digital scale and photographs of ulnas:

- Ulna's weight
- Maximal length – The distance between the highest point of olecranon and the lowest point of ulna's styloid process<sup>3</sup>.
- Physiological length – the distance between the most distal points on the coronoid process surface and on the lower surface of ulna distal end part (excluding styloid process)<sup>3</sup>.

Location of the ideal position for olecranon osteotomy was defined on bones' profile pictures, by measuring the distance from insertion of triceps on the top of the olecranon to the projection of bare area on the posterior wall of ulna (Fig. 3)<sup>8</sup>. Bones with type III bare area were excluded from the sample (when determining the ideal olecranon osteotomy position). Due to connected joint

surfaces, it is not possible to avoid damaging cartilage while performing this procedure. Thus, it is impossible to determine the ideal position for the procedure itself.

The program used for data processing was Statistical Package for the Social Sciences which works under the Microsoft Windows environment. The results are presented using graphs and tables. The descriptive statistics is shown (frequencies and percentages for categorical data, as well as arithmetic means and standard deviations for quantitative data). Since the results of the osteotomy position parameters are expressed quantitatively, it is established that presumption about normal result distribution ( $p > 0.05$ ) was fulfilled using the Shapiro–Wilk test. T-test was used for independent samples to examine differences between male and female ulnas, along with both left and right side of the body in terms of the ideal osteotomy position.  $\chi^2$  test was used for categorical data to determine the correlation between male and female ulnas, the side of the body where the bone is located on one side and the frequency of three basic types of trochlear notch joint surfaces on the other side.

The research was approved by the Medical faculty Ethics commission, in Novi Sad (date: 08 December 2021; decision number: 01-39/119/1).

## Results

According to the bone gender, 45 (65.21%) were males, while 24 (34.79%) were females. The sample contained 37 (52.62%) right and 32 (46.38%) left bones. Descriptive statistical indicators of the measured parameters are shown in table 1.

Type I bare area was represented by 38 ulnas, type II by 20, whereas type III was represented by 11 bones, out of the total number of ulnas in the sample (Fig. 4).

Numerical representation of trochlear notch joint surfaces regarding gender is shown in figure 5. Type I bare area was present in 62% of male ulnas, and 42% at females, type II was noted in 27% of male and 33% of female ulnas, while type III was noticed in 11% of male and 25% of female bones. Statistically relevant connection was not established between male and female ulnas and the presence of three basic trochlear notch joint surface types.  $\chi^2$  (2, N = 69) = 3.335,  $p = 0.189$ .

Joint surfaces frequency distribution in the sample showed that 19 ulnas had type I bare area in both left and right bones, type II was noted seven times in left,



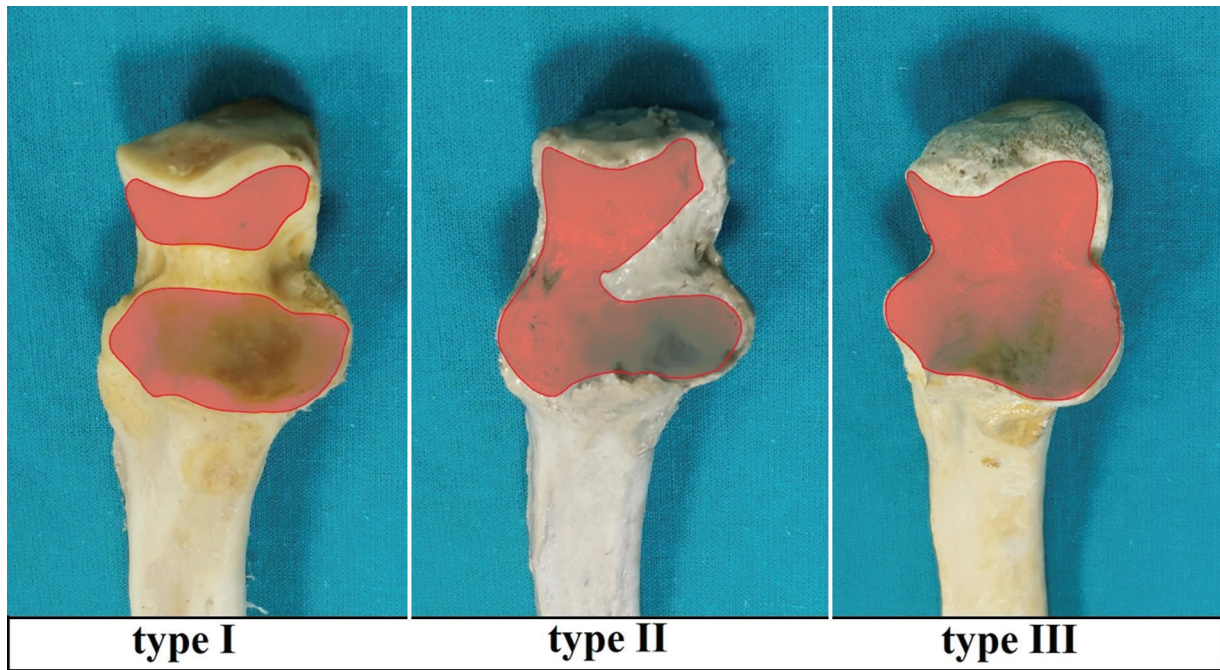


Figure 2. Representation of basic types of trochlear notch joint surfaces.

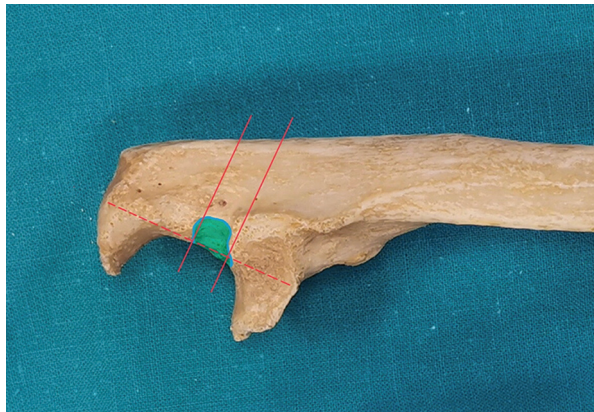


Figure 3. Representation of the bare area projection on the posterior wall of ulna as an entry point for performing the chevron olecranon osteotomy.

and 13 times in the sample of right bones, whereas type III was identified six times in left and five times in right bones. Statistically relevant association between left and right side of the body and frequency of three basic types of trochlear notch joint surfaces were not determined.  $\chi^2 (2, N = 69) = 1.537, p = 0.464$ .

The average value for the ideal position of olecranon osteotomy in the sample (58 bones) was 23.02 mm. In males' ulnas, it was 23.22 mm, while in females, it was 22.59 mm. The results of the t-test indicated that no statistically significant differences were found between

male and female ulnas regarding the ideal average position for performing osteotomy ( $t [56] = 0.619, p = 0.538$ ).

Related to bare area, average value for the ideal position of olecranon osteotomy in type I was 23.31 mm, while in type II it was 22.47 mm. In right ulnas ideal position for performing olecranon osteotomy was 22.61 mm, while in the left bones it was 23.52 mm. The results of the t-test indicated that no statistically significant differences were found between the left and right side of the body in terms of the ideal average position for performing osteotomy ( $t [56] = 0.976, p = 0.333$ ).

## Discussion

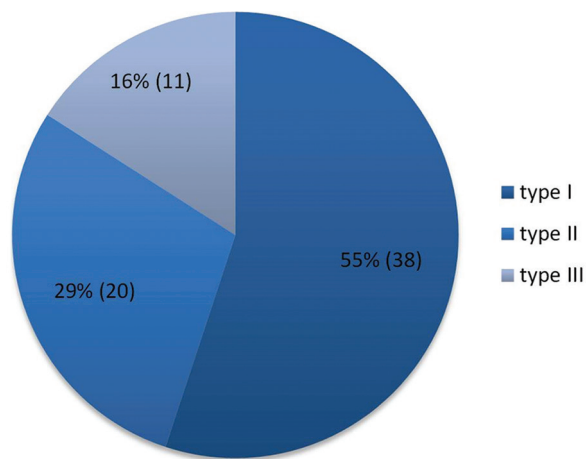
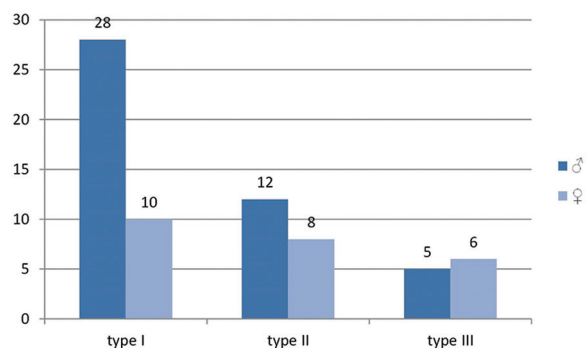
Determination of cadaver sex based on skeletal remains certainly belongs to anthropological sciences. Besides gaining anthropological knowledge, it also provides us with significant forensic data<sup>2</sup>.

In literature, there are several trochlear notch classifications regarding shapes of its joint surfaces<sup>4,5</sup>. Even though classification on three basic types is described in several research papers<sup>5,11</sup>, it is notable that, in anatomical and orthopedics textbooks completely divided, joint surface (type I) is the only one listed<sup>12-14</sup>. We did not find a significant number of scientific papers which included the representation of types of ulnar trochlear notch joint surfaces. Representation of mentioned

**Table 1. Representation of descriptive statistical indicators**

Parameters	n	Min	Max	M	SD
Weight (g)	69	19	74	47.25	13.53
Maximal length (mm)	69	227.73	304.03	261.87	18.35
Physiological length (mm)	69	195.20	271.38	227.85	16.87
Osteotomy position (mm)	58	14.73	31.18	23.03	3.53

N: number of respondents; Min: minimum; Max: maximum; M: arithmetic mean; SD: standard deviation.

**Figure 4.** Representation of trochlear notch joint surface types in our sample.**Figure 5.** Representation of trochlear notch joint surface types according to gender.

structure in Serbian population correlates with the results of other European authors<sup>5</sup>. Both in ours and in mentioned research, types I and II are stated as the predominant, with representation of more than 80%. We believe that knowing the projection of the bare area on posterior wall of the ulna is of crucial importance when performing

olecranon osteotomy, since it is possible to avoid cartilage damage in mentioned trochlear notch types.

In our study, we decided to use bone weight, maximal length of ulna, and physiological length of ulna when determining bone gender. Other researchers showed that two of three mentioned parameters (bone weight and physiological length of bone) are the most discriminatory variables for determining the cadaver gender related to the ulna, with overall accuracy of 93.2%<sup>3</sup>. Due to the significant differences in male's and female's musculoskeletal system, we feel that determination of bones gender is very useful in our study. Type II bare area is relatively equally represented in males and females in Serbian population. Type I was more common in males, while type III was more frequent in female's ulnas. We attribute different bone representation to non-identical biological development of men and women. This result should be taken with certain amount of constraint due to unequal number of bones of both genders.

Types of trochlear notch articular surfaces have a big role in orthopedics surgery. Some authors state different positions as entry point for performing olecranon osteotomy – at the level of the trochlea of humerus<sup>15,16</sup>, then through the trochlear notch itself<sup>17</sup>, as well as 3–4 cm from the top of the olecranon<sup>18</sup>. Newer researches cite the projection of bare area on the posterior wall of ulnas entry point for performing olecranon osteotomy<sup>5,8,10</sup> as a part of operative treatment of fractures of the distal end of the humerus. Based on recent research, we determined the ideal position for olecranon osteotomy based on the projection of the bare area on the posterior wall of the ulna. Compared to our results, Chinese authors report a slightly lower value of the ideal position for performing olecranon osteotomy, which is 22 mm<sup>8</sup>, and we assume that the difference of approximately 1 mm is insignificant. It is our opinion that determining the average position for olecranon osteotomy brings significant data to orthopedists to avoid damage of the articular surfaces, which would certainly lead to certain postoperative complications.

We often come across authors' hypotheses that different anatomical characteristics can be found among the same bones, on opposite sides of the body (right and left bones)<sup>19</sup>. Yet, there is a relative uniformity of the types of articular surfaces of the trochlear notch between the left and right ulnas in our sample. Six more right bones with the type II trochlear notch are due to the fact that there were more right ulnas in the entire sample. In literature, authors use different names to describe the part of the articular surface

without cartilage, that is, the bare area itself. However, its name does not exist in the official anatomical literature<sup>9</sup>. Based on the anatomical structure of the liver, the *area nuda*, we feel that a uniform name for the bare area should be established. Considering its anatomical appearance and histological structure<sup>14</sup>, we suggest the name *area ossea*. The new, specific name would greatly contribute to a better understanding and easier identification of the described structure.

## Conclusions

Type I bare area is the most common type of articular surface in Serbian population. The average value for the ideal position of olecranon osteotomy in the sample was 23.02 mm, and no statistically significant differences were found between male and female ulnas regarding the ideal average position for performing osteotomy. Furthermore, no statistically significant differences were found between the left and right side of the body in terms of the ideal average position for performing osteotomy. We believe that knowing the projection of the bare area on posterior wall of the ulna is of crucial importance when performing olecranon osteotomy, since it is possible to avoid cartilage damage in different trochlear notch types. The new special name *area ossea*, which we suggest for the examined structure, would greatly contribute to a better understanding and easier identification.

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## Conflicts of interest

All authors declare that they have no conflicts of interest.

## Ethical disclosures

**Protection of human and animal subjects.** The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical

research ethics committee and with those of the Code of Ethics of the World Medical Association (Declaration of Helsinki).

**Confidentiality of data.** The authors declare that they have followed the protocols of their work center on the publication of patient data.

**Right to privacy and informed consent.** The authors have obtained approval from the Ethics Committee for analysis and publication of routinely acquired clinical data, and informed consent was not required for this retrospective observational study.

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