Orgınal Article

Evaluation of morphological changes on the proximal part of the ulna from the 13th century to the contemporary

13. yüzyıldan günümüze proksimal ulnadaki morfolojik değişikliklerin değerlendirilmesi

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Highlights

• Due to external factors such as lifestyle, nutrition and climate changes, bones may show morphological differences between individuals.

• In particular, functionally changing muscle strength due to different lifestyles causes anatomical changes on the bones.

Abstract

Background: The aim of the study is to evaluate the proximal part of the ulna bone of the present and 13th century Byzantine period using the attachment points of the muscles and to evaluate the morphological changes.

Materials and Methods: A total of 81 ulnae, 29 of which belong to the contemporary and unknown gender, and 52 from the thirteenth-century late Byzantine period are included in the study. The parameters were measured in millimeter on the photos with the ImageJ software. For the statistical analysis, SPSS 22.0 (IBM) software was used (p<0.005).

Results: The descriptive values of the variables were given as mean±standard deviation and minimum-maximum values. According to the results of the statistical analysis, there is no difference in the right and left sides. Except for the angle between the the most prominent anterior point of the olecranon (MAPO) - the most posterior point of the olecranon (MPPO) - the point of the maximum anterior angulation (MAA) parameter, the rest of the parameters were higher in the Byzantine period ulnae.

Conclusions: In this study, we showed the period differences on the proximal part of the ulna especially the olecranon because of the using the extensor muscle of the forearm and the stabilizer muscle of the elbow. We believe that the data obtained will functional perspective help different disciplines, especially anthropologists and anatomists.

Keywords: Ulna, Byzantine, contemporary, proximal, morphometry

ÖZ

Amaç Çalışmanın amacı, günümüz ve 13. yüzyıl Bizans dönemine ait ulna kemiğinin proksimal kısmının kasların bağlantı noktaları kullanılarak değerlendirilmesi ve morfolojik değişimlerinin incelenmesidir. **Gereç ve Yöntem:** Cinsiyeti bilinmeyen 29 tanesi günümüze ait ve 52'si 13. yüzyıl geç Bizans dönemine ait olmak üzere toplam 81 ulna çalışmaya dâhil edilmiştir. Parametreler, ImageJ yazılımı ile fotoğraflar üzerinde milimetre cinsinden ölçülmüştür. İstatistiksel analiz için SPSS 22.0 (IBM) programı kullanılmıştır (p<0.005). **Bulgular:** Değişkenlerin tanımlayıcı istatistikleri ortalama±standart sapma ve minimum-maksimum değerler olarak verilmiştir. İstatistiksel analiz sonuçlarına göre sağ ve sol tarafta fark bulunmamıştır. Olecranon en belirgin ön çıkıntısı (MAPO) - olecranon arka çıkıntısı (MPPO) - maksimum ön açılanma noktası (MAA) arasındaki açı değeri dışında diğer parametreler Bizans dönemi ulnae'de daha yüksek değerlere sahip olarak belirlenmiştir. **Sonuç:** Bu çalışmada, ön kolun ekstansör ve dirseğin stabilizatör kasının kullanılması nedeniyle ulna proksimal kısmında özellikle olecranon üzerindeki periyod farklılıklarını gösterdik. Elde edilen verilerin başta antropolog ve anatomistler olmak üzere farklı disiplinlere fonksiyonel açıdan yardımcı olacağına inanıyoruz.

Anahtar kelimeler: Ulna, Bizans, günümüz, proksimal, morfometri

Introduction

The morphological diversity of an anatomical structure is determined by the specific requirements of the human body from the anthropometric or functional perspectives (1). All tissues undergo morphological changes as a result of phylogenetic and ontogenetic factors in accordance with function (2). After human adaptation to bipedalism, the load lifted from the upper extremities has also allowed the development of fine motor skills (3). The realization of these skills at the motor function level occurs due to the coordination of different joints and muscles in spatial patterns (4). Anthropometric analyzes are performed to evaluate certain indices necessary to describe morphometric variability in humans. Human bones are very important in physical anthropological studies, forensic science studies and surgical planning (5). The ulna is one of the forearm bones located on the medial side in the anatomical position. It is accepted that the strongest and thickest part of the bone is the proximal part. It plays a significant role in the formation of the elbow joint and wrist joint and its anatomical geometry is of great concern (6). The triceps brachii is the only muscle on the back of the arm and acts as the strongest extensor of the forearm. The muscle, which begins as three heads (long, lateral, and medial heads) on the scapula and humerus, ends distally on the olecranon located on the head of the ulna (7). Another muscle of the back of the elbow is the anconeus. It begins from the lateral condyle of the humerus and inserts into the olecranon and the proximal part of the dorsum of the ulna (8). While the triceps brachii muscles act as an extensor, the anconeus provides stabilization of the elbow and abduction during the pronation and supination movements of the ulna (9). From a different perspective, forensic identification is among the important issues that forensic sciences and anthropologists deal with. Here, biological characteristics such as age, gender, ethnicity and etc. gain more importance (10). Periodic changes detected on the bones can also be used for identification, especially on the age factor.

The aim of the study is to evaluate the proximal part of the ulna bone of the present and 13th century Byzantine period using the attachment points of the muscles and to evaluate the morphological changes in the bone, especially the effects of the triceps brachii muscle, with morphometry by making a period comparison. In this way, we aimed to determine possible lifestyles and, therefore, possible functional changes on bones of the past centuries. As far as we know, there is no other study similar to the one we looked at from a different perspective.

Material and Methods

A total of 81 ulnae in the Department of Anatomy, Bursa Uludag University, Faculty of Medicine, 29 (12 left, 17 right) of which belong to the contemporary and unknown gender, and 52 (20 left, 32 right) from the 13th late Byzantine period and thought to be all soldiers were included in the study. Skeletal remains were excavated in the amphitheater located in the Bursa/Iznik Saraybahce district by Prof. Dr. Metin Ozbek, an instructor of the Department of Anthropology at Hacettepe University, in 1984 (13). When determining the parameters to be measured certain landmarks were chosen; the most prominent anterior point of the olecranon (MAPO), the most posterior point of the olecranon (MPPO), the point of the maximum anterior angulation (MAA) **(Figure 1)**. The following parameters were respectively **(Figure 2)** (11,12):

P1) The distance between the most prominent anterior point of the olecranon (MAPO) and the distal point of the ulnar styloid process

P2) The distance between the most posterior point of the olecranon (MPPO) and the distal point of the ulnar styloid process

P3) The distance between the point of the maximum anterior angulation (MAA) and the distal point of the ulnar styloid process

P4) The vertical distance between the MPPO and the MAA

P5) The angle between the MAPO-MPPO-MAA

P6) The angle between the posterior border of the ulna line using the MAA and the linear distance between MPPO- MAA. The bones which have deformities or fractures were excluded from the study. The photographs of the bones were taken with the Nikon D5000 camera with the standard position using the ruler on one side to provide calibration. The parameters were measured in millimeter on the

photos with the ImageJ software. For the statistical analysis, SPSS 22.0 (IBM) software was used ($p<0.005$). Shapiro Wilk test was used to show the normality distrubutions of the variables. To evaluate the period differences Students' T-test and the Mann Whitney-U test were used. Using Spearman's correlation test, the correlation between the parameters was determined for the contemporary and Byzantine periods separately. The angle between the MAPO-MPPO-MAA (P5) was non parametric for both contemporary and 13th century. The distance between the MAA and the distal point of the ulnar styloid process (P3) was not normally distrubeted in the 13th century bones.

Results

According to the results of the statistical analysis, there was no difference in the right and left sides, so the data were examined without considering the side difference (Table 1). The descriptive values of the variables were given as mean ± standard deviation and minimum-maximum values in Table 2. According to the Shapiro-Wilk test, P3 and P5 were non-parametric parameters. When we examined the results, except for the angle between the MAPO-MPPO-MAA parameter, the rest of the parameters were higher in the Byzantine period ulnae. The angle between the MAPO-MPPO-MAA just had a high mean value in the contemporary. When we examine the results to reveal the period difference we saw that the distance between the MPPO and the distal point of the ulnar styloid process (P2), the distance between the MAA and the distal point of the ulnar styloid process (P3), and the angle between the MAPO-MPPO-MAA (P5) were shown differences **(Table 1).** When the correlation values for contemporary and Byzantine period bones were examined separately, the P1 and the P2 parameters were correlated with each other. For the contemporary R-value was 0.972 and for the Byzantine period bones, it was 0.982. The correlation between the P1 and P3 were R=0.862 and R=0.811, for the P2 and P3 R values were R=0.869 and R=0.819 respectively. It was seen that the angle between the MAPO-MPPO-MAA (P5) and the angle between the posterior border of the ulna-line passing through the MAA and MPPO- MAA (P6) had a low and negative correlation with each other in contemporary (R=-0.502) but this relationship was not seen in the Byzantine period. In the same way, it was seen that between the P1-P4 (the vertical distance between the MAA and the MAPO), and P2-P4 there were low correlations (R=0.448 and R=0.418, respectively) but in contemporary, there were not any correlation.

Table 1. Descriptive values of the variables according to the side in millimeter (p<0.005)

Parameter	Contemporary			Byzantine		
	R	L	p value	R	L	p value
1	233.07 ± 15.75	232.51 ± 17.25	0.928	249.26 ± 19.42	251.10 ± 17.88	0.735
2	225.95 ± 15.81	226.35 ± 15.73	0.951	244.52 ± 18.17	246.23 ± 17.29	0.986
3	186.21 ± 13.32	188.86 ± 19.04	0.663	200.89 ± 13.74	204.26 ± 20.20	0.481
4	47.89 ± 8.40	43.47 ± 6.67	0.141	49.72 ± 11.14	47.50 ± 9.44	0.465
5	115.70 ± 5.58	119.74 ± 8.05	0.121	112.38 ± 7.74	114.77 ± 7.00	0.531
6	7.34 ± 2.77	7.07 ± 3.03	0.859	8.45 ± 3.52	8.09 ± 3.34	0.714

Table 2. Descriptive values of the variables in millimeter (p<0.005)

Parameter	Contemporary		Byzantine		
	Mean ± S.D.	Min. - Max.	Mean ± S.D.	Min. - Max.	p value
1	232.84 ± 16.08	188.72 - 278.75	249.98 ± 19.52	188.72 - 278.75	0.146
2	226.13 ± 15.49	205.71 - 281.20	245.19 ± 17.68	205.71 - 281.20	0.001
3	187.31 ± 15.67	168.72 - 275.42	202.22 ± 16.46	168.72 - 275.42	0.001
4	46.07 ± 7.92	29.30 - 72.70	48.85 ± 10.47	29.30 - 72.70	0.218
5	117.37° ± 6.88°	87.37° - 135.63°	113.31° ± 7.48°	87.37° - 135.63°	0.023
6	7.23° ± 2.83°	1.01° - 19.88°	8.31° ± 3.42°	1.01° - 19.98°	0.151

Abbreviations: S. D.; Standart deviation, **Min.;** Minimum, **Max.;** Maximum
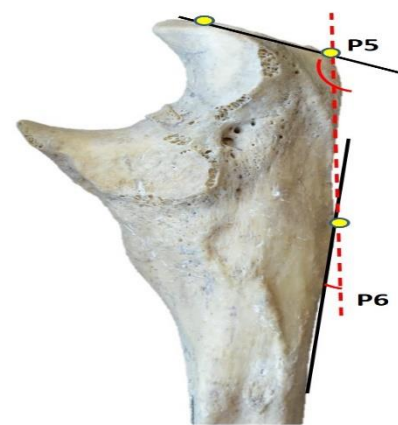
Figure 1. The definitons of the landmarks   Figure 2. Measured parameters on the ulna

Aberrivations: **MAPO**; the most prominent anterior point of the olecranon, **MPPO**; the most posterior point of the olecranon, **MAA**; the point of the maximum anterior angulation

Discussion

In this study, we showed the period differences on the proximal part of the ulna, especially the olecranon. It is aimed to determine the biological profiles of individuals belonging to the Byzantine period, as well as to reveal the changes that have occurred as a result of the intervening centuries from an anatomical perspective.

Muscles, which reveal the function of an organism, are anatomical structures that can be used in the examination of morphological changes that occur or may occur in the human body structure. Muscle attachment marks in bones can provide complementary information about both individual differences and individuals in ancient times. This information can shed light on the function of skeletal elements so the size of soft tissues, and life habits (14). External factors such as climate change, nutrition, population growth, emerging diseases and mutations that may occur in genes or epigenetic factors can cause morphological differences between periods (15).

In the study, it was observed that P1, P2 and P3 parameters showed a period difference and these values were higher in Byzantine bones. Interestingly, the vertical distance between the MAA and the MAPO did not show the period difference. In the morphometric study we conducted using the whole ulna before, we reached the data that all values were higher in Byzantine bones. In the study where we measured the vertical distance between the horizontal plane passing over MAPO and the styloid process, we measured the ulna length as 25.68 cm on the right, 25.56 cm on the left, and 23.35 cm on the right and 22.91 cm on the left in Byzantine bones (16). In this study, the directly measured distance between MAPO and the styloid was found to be a mean of 249.98 mm in Byzantine bones and 232.84 mm in contemporary bones. The results of our study using different parameters in the same bones support this information.

On the other side, while the P5 had a difference, the P6 had not. P5 has a narrower angle in Byzantine bones, but it is seen to have a wider angle in contemporary. This result made us think that the MAA point was more anterior in Byzantine bones, that is, the back of the bone had a flatter structure. Considering that the bones belonging to the Byzantine period are thought to belong to the soldiers and the people living in this period were engaged in agriculture, it is not surprising to see the effect of muscles in the bones of these individuals. When we look at this situation from a different perspective,

it may be possible that the MPO is positioned higher and this may cause the P5 to be narrower angled in the Byzantine bones.

Correlation analyses showed that while there was a low correlation between P4 (the vertical distance from the MAPO-MAA) and P1 and P2 in Byzantine bones, there was no such relationship in contemporary bones. On the contrary, while there was no correlation between the angular parameters between P5 and P6 in Byzantine bones, a negative correlation was determined in contemporary bones. It is reported that the individuals belonging to the Byzantine period bones were soldiers and were engaged in jobs that required intense manpower, such as farming (13). Depending on the dominant function of the biceps brachii muscle, the presence of stronger flexion movement and straightening of the back are expected for us. Similarly, due to the expected dominant extension due to the triceps brachii muscle, the MAPO point may be located higher. It is possible that the anconeus, which is the stabilizer muscle of the region, establishes the balance. Today, due to the deterioration of this balance, the fact that there are changes between the angles can be accepted as an indicator of the change.

It is possible to say that the bones of the Byzantine period, belonging to the late 13th century, have shortened in the 800-year period between the present day. In the literature, there is information that human height varies according to race and even countries regarding ancient populations (17). Considering that there are many factors related to height, it is not appropriate to say that the neck has shortened over the period.

The parameters selected for the study are the basic and also functional anatomical points due to the muscles attached to the region in the proximal part of the ulna. In the literature, there are studies on plate design for proximal part of the ulna, especially olecranon fractures (18,19). In this study, we evaluated the ulna anatomy from a different perspective by showing an anthropometric approach. We have shown the effect of the changes in lifestyle with the changing centuries on the proximal part of the ulna. Again, from the point of view of forensic sciences, we think that data can be used from different angles by different disciplines. We believe that the data obtained will functionally help different disciplines, especially anthropologists and anatomists.

Study Limitations

Limitations of this study are the low number of bones and the unknown gender. This study, which has been examined from a functional point of view, will bring different perspectives in case of higher number of bones and especially gender determination.

Conclusions

Many factors such as lifestyle, diet and climate differences affect the bones morphologically. In this study, we showed the effect of the period difference on the proximal part of the ulna using bones from the Byzantine period and contemporary's bones. It is expected that the bone anatomy of this group, which is more engaged in agriculture and has a different diet than today, is different from people of contemporary.

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