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SUCCESS OF LONG BONE FRACTURE HEALING IN ANCIENT EGYPT: A PALEOEPIDEMIOLOGICAL STUDY OF THE GIZA NECROPOLIS SKELETONS

USPJEŠNO ZARASTANJE DUGIH KOSTIJU U STAROEGIPĆANA – NALAZI PALEOEPIDEMIOLOŠKOG ISTRAŽIVANJA NA KOSTURIMA IZ NEKROPOLE U GIZI

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Summary

Complications may provide information regarding the management of fractures in ancient populations. The aim of this study was to determine the rates of long-bone fractures and the proportion of misalignments as indicators of failed treatment or no treatment at all in skeletons from the Giza Necropolis dating to the Old Kingdom period (2700-2190 BC).

We visually examined for fractures 2287 long bones of 204 adult skeletons (112 male and 92 female) and took x-rays of fractured bones in standard AP and ML views, so that we can analyse misalignments.

Fractures were found in 45 of the 2287 examined long bones (1.97 %). Most of the fractures healed with good alignment, most likely as a result of successful treatment, and only three fractures showed misalignment.

***Key words**: History of medicine; Ancient Egypt; paleopathology; fractures*

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Introduction

Human skeletal remains can be used to reconstruct the demographics, lifestyle, and illnesses and their treatment in past populations. For instance, from ancient Egyptian remains we learn that life expectancy in the Dynastic Period was about 36 years [1]. Diagnosis and localisation based on pathoanatomic descriptions from sources predating x-ray are not reliable, and interpretation into modern scientific terms like proximal fracture, shaft fracture, distal fracture, glenohumeral dislocation, or fracture-dislocation requires a degree of reserve. Skeleton study, using modern methods such as x-ray, is a useful complement to written sources, whose interpretation is otherwise often difficult or even misleading.

One of the oldest remaining texts on surgical treatment of trauma is the Edwin Smith Papyrus from the 17th century BC [2]. Discovered outside of Luxor, Egypt in 1862, it gives us a remarkable insight into the medical practice of ancient Egyptians on the Nile. The Papyrus is divided into 48 cases, most of which describe traumatic injuries. The text instructs the physician to examine the patient and look for physical signs that may indicate the location of injury. Second to degenerative changes, trauma is the most common pathological condition found in archaeological skeletons [3,4]. Considerations about the cause of trauma must include the characteristics of the fracture itself. Differences in fracture patterns and prevalence in past populations have long been studied to identify cultural differences such as those related to health and lifestyle [5-7].

Knowledge about fracture treatment, its success and failure, is modest when it comes to ancient Egyptians from the Old Kingdom period [8]. The aim of our study was to address this gap, by looking into the cases of failed fracture treatment through misaligned bone healing in the Egyptian population from that era.

Material and methods

We examined 204 ancient Egyptian skeletons from the Old Kingdom period (2700-2190 BC), known as the period of pyramid builders. They were excavated from the Giza Necropolis by the Hearst Expedition led by Professor Reisner in 1902-1905 and by the Egyptian Supreme Council of Antiquities [9]. The Giza Plateau with three pyramids and the Necropolis is located some 20 kilometres to the southwest of Cairo.

We first visually examined the long bones for fractures, 2287 in total, and x-rayed the fractured bones in standard views, anteroposteriorly (AP) and mediolaterally (ML) for more information about the trauma. In the misaligned bones, we measured the direction and degree of angulation at the fracture site with a goniometer in both radiograph views. A misalignment refers to a fracture that heals leaving a deformity because the fracture has not been reduced or the reduction was not maintained, leaving fragments to heal grossly angulated or excessively shortened. Shortening is caused by overlap, substantial angulation, crushing, or gross bone loss.

The sex of the skeletons was determined using the descriptive methods of the skull and pelvis [10]. Age at death was estimated from auricular surface metamorphosis and from the pubic symphysis [11,12].

Results and Discussion

Table 1 shows the distribution of long-bone fractures by bone and sex. Fractures were found in 1.97 % of the examined long bones, but this frequency should be taken with reserve, as 569 bones were missing to have a complete picture of long-bone fractures in the 204 skeletons. Still, fracture distribution by bone may provide some information about common long-bone traumas of the time. The most common were the fractures of the ulnae (13.1 %), quite likely as a result of acute trauma provoked by a fall or similar unfortunate occurrence [13]. Follow the fractures of the radii (7.1 %) and fibulae (4.2 %), with single cases of femur, clavicle, and tibia fractures. The overall frequency of bone fractures does not seem to differ between the sexes.

The overall prevalence of fractures was 18 % (in 37 of 204 skeletons, see Table 2). Table 2 also shows that the prevalence of fractures did not differ visibly between men and women, but confirms earlier paleoepidemiological reports of increased fracture risk with age and/or fracture accumulation over a lifetime [14,15]. Again, some reserve is advised, as fractures noted in older age groups may have occurred at younger age.

Table 1. Distribution of long-bone fractures by bone and sex
(*n/N = number of affected bones / number of examined bones*)

Tablica 1. Učestalost prijeloma prema kosti i spolu
(n/N = broj slomljenih kostiju / broj pregledanih kostiju)

Bone	Men		Women		Total	
	n/N	%	n/N	%	n/N	%
R. ulna	14/102	13.7	5/81	6.2	19/183	10.4
L. ulna	2/102	2.0	3/81	3.7	5/183	2.7
R. radius	4/97	4.1	1/73	1.4	5/170	2.9
L. radius	0/98	0.0	7/68	10.3	7/166	4.2
R. clavicle	0/85	0.0	0/67	0.0	0/152	0.0
R. Humerus	0/99	0.0	0/77	0.0	0/176	0.0
L. humerus	0/99	0.0	0/80	0.0	0/179	0.0
L. clavicle	1/79*	1.3	0/72	0.0	1/151	0.7
R. femur	1/92*	1.1	0/72	0.0	1/164	0.6
L. femur	0/91	0.0	0/69	0.0	0/160	0.0
R. tibia	0/88	0.0	0/70	0.0	0/158	0.0
L. tibia	1/89*	1.1	0/70	0.0	1/159	0.6
R. fibula	0/79	0.0	0/64	0.0	0/143	0.0
L. fibula	6/80	7.5	0/63	0.0	6/143	4.2
Total	29/1280	2.3	16/1007	1.6	45/2287	1.97

* *healed fractures with misalignment*

Table 2. Distribution of fractures by age and sex
(*n/N= number of affected skeletons / number of examined skeletons*)

Tablica 2. Učestalost prijeloma prema dobi i spolu
(n/N = broj kostura s prijelomom / broj pregledanih kostura)

Age group (y)	Men		Women	
	n/N	%	n/N	%
20 - 29	0/14	0.00	2/22	9.09
30 - 44	13/64	20.31	8/40	20.00
≥ 45	8/34	23.52	6/30	20.00
Total	21/112	18.75	16/92	17.39

Figure 1 - Healed oblique fracture of right femur with bad alignment and linear deformity with a 15-degree interior angulation in an adult male aged 40-50 years

Slika 1. Nepravilno srastao prijelom desne bedrene kosti s devijacijom osi od 15 stupnjeva prema unutra u odraslog muškarca u dobi od 40 do 50 godina

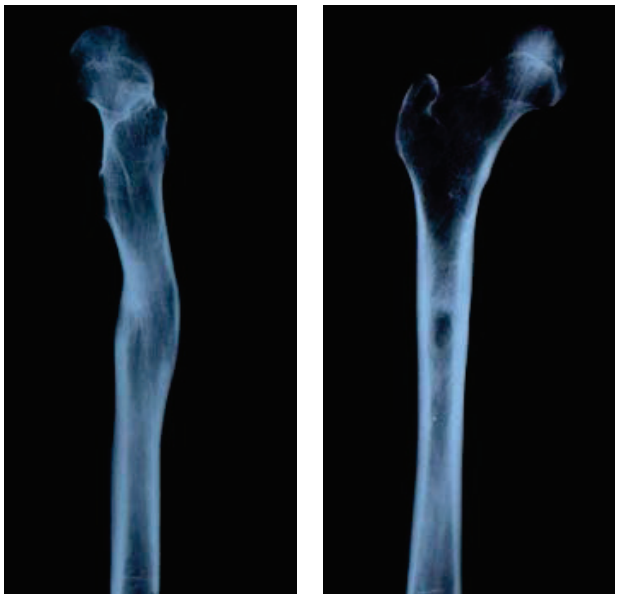

Figure 2 - Antero-posterior (a) and lateral (b) view of the misaligned femur

Slika 2. Anteroposteriorni (a) i lateralni (b) RTG nepravilno zarasle bedrene kosti

Of the 45 fractures confirmed by x-rays, three were misaligned and concern the three single cases of femur, clavicle, and tibia fractures (Figures 1-6). Figure 1 shows a healed oblique fracture in the proximal shaft of the femur of a man aged 40-50 years at the time of death and Figure 2 the corresponding AP and ML radiographs of the fractured femur with linear deformity at 15° interior angulation. The fracture was probably caused by severe direct trauma and was complicated by simultaneous hip dislocation as observed visually. A similar misalignment of the right femur was reported in an adult Australian male aged 50, who lived about 1000 years ago [16]. It indicated that the fracture occurred in one traumatic event, perhaps life-threatening, and that the subject survived for years after this incident, despite no or failed treatment. Stern [17] reported that femoral shaft fractures are associated with high-energy trauma, since the femur is the most densely mineralised bone and the most difficult to break. Moreover, Judd [18] reports that femur fractures accounted for the highest number of complications in the Kerma skeletons.

The second misalignment (Figure 3) concerns a healed oblique fracture in the mid shaft of the clavicle of a 50+-year-old man at the time of death. Figure 4 shows superior-inferior and AP radiographs of the fractured clavicle with spiral rotational deformity at 18° anterior angulation. A fall on the shoulder is the most probable cause. Historically, the treatment of these fractures was conservative. Case #35 in the Edwin Smith Papyrus describes fractured clavicle treatment as follows:

Figure 3 - Healed oblique fracture of left clavicle with spiral rotational deformity and 18-degree anterior angulation in an adult male aged 50+ years

Slika 3. Nepravilno srasla lijeva ključna kost sa spiralnom torzijskom deformacijom i prednjom devijacijom od 18 stupnjeva u odraslog muškarca starijeg od 50 godina

> *Place him prostrate on his back with something folded between his shoulder blades; thou shouldst spread out with his two shoulders to stretch apart his collarbone until the break falls in its place. [2]*

Fracture injuries often improve with time, but misaligned clavicle fractures in archaeological skeletons do not necessarily point to the absence of medical treatment, as treatment of clavicle fractures often resulted in some deformity [19,20].

Figures 5 and 6 show the third case of misalignment, this time of a fractured tibia. This oblique fracture was at the proximal epiphysis and healed with linear deformity at 44° laterally. When isolated and not involving the fibula, these tibia fractures may be caused either by a fall or by a direct blow to the leg, but when they do

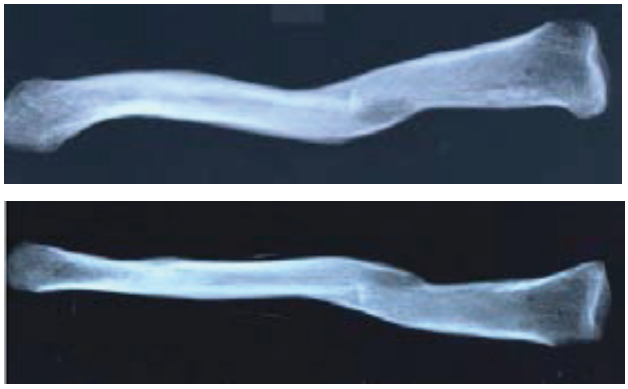

Figure 4 - Superior-inferior (a) and anteroposterior (b) view of the misaligned left clavicle

Slika 4. Superiorno-inferiorni (a) i anteroposteriorni (b) RTG nepravilno srasle lijeve ključne kosti

Figure 5 - Healed tibia with bad alignment and linear deformity

Slika 5. Nepravilno srasla goljenična kost s devijacijom osi

involve the fibula, a more likely cause is the fall from a low height [21,22].

In an article published in *British Medical Journal* in 1908 [23], Eliot-Smith speaks about the successful treatment of fractured bones in ancient Egyptians with splints. Splints were rigid tubular cases of palm fibre or stiff linen rolls. As early as the fifth dynasty of the Old Kingdom, splints were applied in the treatment of forearm fractures and the design remained unchanged until after the Christian period [24]. Yet, numerous examples of misaligned but healed fractures in archaeological skeletons have been reported [25-27].

The ancient Egyptians also used bandages to stabilise long-bone fractures. Hippocrates, who wrote extensively about the principles of bandaging and the importance of changing the bandages fairly frequently, refined this type of treatment [28].

The overwhelmingly successful healing rate in our study is in line with historical reports such as those of Eliot-Smith [23] that long-bone fracture treatment methods in ancient Egypt were efficient. On the other hand,

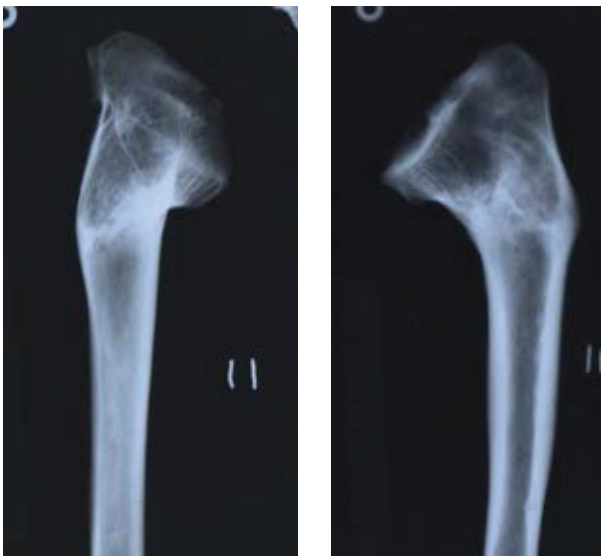

Figure 6 - Lateral (a) and antero-posterior (b) view of the misaligned tibia

Slika 6. Lateralni (a) i anteroposteriorni (b) RTG nepravilno srasle goljenične kosti

fractures of the radius and ulna – which made 80% of all fractures in our study – are rather easy to treat, even with the simplest methods such as slings, whereas the treatment of clavicle, tibia, and femur fractures is far more difficult, as has been corroborated by our findings.

Our future investigation may have to take a closer look at fracture differences between the sexes and see if they were related to gender roles.

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Sažetak

Komplikacije nastale nakon obrade lomova kosti u starih naroda govore nam o načinu i uspješnosti njihova liječenja. Cilj je ovog istraživanja bio utvrditi učestalost prijeloma kosti i komplikacija proizišlih iz liječenja ili izostanka liječenja u kostura iz grobnice u Gizi iz razdoblja Starog egipatskog kraljevstva (2700.–2190. pr. n. e.).

U potrazi za prijelomima pregledali smo 2.287 dugih cjevastih kostiju 204 odrasla staroegipatska kostura (112 muških i 92 ženska). Krivo sraštene kosti potvrđene su rendgenski.

Prijelomi su utvrđeni na 45 od 2.287 pregledanih kostiju (1,97 %). Većina je prelomljenih kostiju pravilno srasla zahvaljujući uspješnom liječenju, a tek je u tri prijelom srastanje bilo krivo.

Ključne riječi: *povijest medicine, Stari Egipat, paleopatologija, prijelomi kosti*