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Ligamentum capitis femoris: first written mentions

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SUMMARY

Background. A ligamentum capitis femoris (syn. ligamentum teres) is one of the least studied anatomical structures. We know little about its role in the musculoskeletal system, and even less about its first written mentions. **Purpose.** This article is intended to clarify who and when first described the connection of the head of the femur in the medical literature, and to provide a hypothesis about its first mention in the history of mankind. **Material and methods.** We reviewed the oldest written sources available to us, covering the anatomy of the hip joint and ligamentum capitis femoris. **Conclusion.** The first description of the ligamentum capitis femoris in the medical text is given by Hippocrates of Kos in the treatise Instruments of Reductions (V-IV century BC). According to our hypothesis, the first in the history of mankind to mention a ligamentum capitis femoris, is contained in the ancient literary monument of Torah (XII-II century BC), there it is first reported about its damage, which led to disruption of walk biomechanics. The article will contribute to the further study of the ligamentum capitis femoris, the search for effective methods of treatment and prevention of its pathology.

KEY WORDS

Ligamentum capitis femoris; biomechanics of hip joint; gait pathology; history of medicine

INTRODUCTION

In the human hip joint, there is a ligament which in Latin is called ligamentum capitis femoris (LCF) (syn. ligamentum teres), connecting the head of femur and the acetabulum. This is one of the least studied anatomical structures of the human body, indeed, a ligamentum incognita. The existing opinions on the role of the LCF in the musculoskeletal system are diametrically opposed. According to one viewpoint, it is an atavistic structure without a determined function (1,2), according to the opposite opinion, it is an important element of stabilization of the hip joint (HJ) (3) and of pelvis stabilization in the orthostatic positions and during walking, which provides optimal load distribution on the HJ surfaces (4). The modern scientific research point to the possibility of a gait disorder in the case of the LCF pathology (5,6). The relation between alteration of the walking stereotype and injury of the LCF, convinced us in the necessity of a study of the HJ biomechanics, taking into account the role of the ligamentous apparatus (7). Having studied the role of the LCF in the musculoskeletal system, we noticed a growth in the number of publications on this anatomical element in the beginning of the XXI century. We explicated this fact to enhanced resolution of magnetic resonance tomography and development of the HJ arthroscopy, which allow studying LCF in vivo (5,6,8). The lack of understanding of the exact cause of osteoarthritis, including osteoarthritis of HJ, also draws attention to this structure, as well as the cause of gait disorders in this disease (7,9,10). The search for a primary component of the coxarthrosis pathogenesis and finding the regularities of alteration of the normal locomotion stereotype more precisely leads us to LCF (7). It is still unknown how long ago the humankind has discovered the LCF and thought about its role in the musculoskeletal system.

This work submits to the ethical standards of the Muscles, Ligaments and Tendons Journal (11).

The first mentions in ancient medical literature

The first scientific description of LCF in the medical literature is present in the treatis Μοχλικός (*Instruments of Reduc-*

tions), authored by Hippocrates of Kos (b. 460 BC) (12). In the Greek edition of the manuscript, LCF is called νεῦρον (13), while in the Latin version it is referred to as *neruus* (14). One of the early LCF mentions is contained in the work by Apollonios of Kition Περὶ αρθρων Πραγματεὶα (15) (*Treatise on Joints*), written during the rule of King Ptolemy who reigned in Cyprus (81–58 BC)(16). When discussing the importance of LCF, Apollonios of Kition refers to the viewpoint of a more ancient author, a surgeon named Hegetor (17), who practiced in Alexandria (Egypt) about 130 BC (18). There, in Greek, LCF is referred to as νεῦρον and there is a notice that it is damaged when the hip is dislocated (15), when translated to Latin, LCF is called *nervum* (17). C. Galen (130–200/201 AD)(19) in *Galeni in Hippocratem de articulis commentaius quartus*, quoted an even more ancient author – Heraclides of Tarentum (III–II century BC)(19), he also wrote about LCF, which in Latin was called *neruus* (20). A.Vesalius (1568) explains the use of those terms as follows: νεῦρον is an analogue to the Latin *nervus* and is also applied to "*ligaments connecting bones*"(21).

The first description in the history of mankind

In our opinion, the first in the human history mention of LCF is contained in the book of *Bereshit*, a part of the *Torah*, which was "*revealed to Moses … in about 1280 BC*" (22). According to the existing consensus, the literary monuments forming the *Torah* (part of the *Old Testament* or *Pentateuch*) are dated from XII–II century BC (23). From the book of *Bereshit* we learn that Patriarch Jacob (Israel) suffered an injury of some anatomical structure – "גִּיד הַנָּשֶׁה" (*gid hanacheh*) (Ber. 32:33) (24), related to HJ. The translation of "הַנָּשֶׁה" (*hanacheh*) from Hebrew reads "*he that is in a loose, relaxed*", while "גִּיד" (*gid*) means – *sinew* (25). The term *gid*, in respect to the biblical text, is presently translated not only as sinew (24), but also as muscle (26), tendon (27), vein and nerve (28). J.Preuss notes that the Hebrew *gid*, Roman *nervus*, Greek *neuron*, and Arabian *irk* are known to be applied to nerves, tendons and ligaments (29). According to the *Talmud,* the word *sinew* means – tendon, ligament, nerve and even blood vessel and is related to an anatomical structure "*that is long and stringlike*", though, as Rav. Yehudah points: "*…we do not know with certainty which one it is*" (30).

As the *Letter of Aristeas* (130–70 BC) mentions, the first translation of the *Torah* to Greek, which was entitled *Septuaginta (LXX)*, was performed during the rule of King Ptolemy II Philadelphus (285–247 BC) in Alexandria in a northern district of the island of Pharos (31). In the *Septuaginta, gid* is translated as νεῦρον (Γέν. 32:33) (32). In a Latin translation, which followed towards the end of the IV century BC,(22) known as the *Bible*, *gid* is called *neruum (*33). In the course of the *Torah* translation from Hebrew to Greek in Alexandria, Herophilus (330/320–260/250 BC), an Ancient anatomist authority, conducted detailed dissections of a human body (34). The Hegetor and Heraclides of Tarentum, a Herophilus's followers, was of representatives of the Alexandrian medicine, knew exactly about LCF, Apollonios of Kition and C.Galen, studied at the same place, mentioned it in writing (16,17,19,20). The localization inside the HJ, consistency of the terms used in the early the *Bible* translations and in the antique medical literature, allow us to conclude that the book of *Bereshit* discusses LCF (12,15,17).

An evidence for our point of view is a detailed description of the injury suffered by Patriarch Jacob, in the *Bible*. This description resembles a fragment of a dramatic medical history of a man with an LCF injury. We know that it was a family man named Jacob ben Isaac ben Abraham, according to the *Book of Jubilees* (153–105 BC), born in 2046 AM (31) (circa 1714 BC, see Note). By profession, he was a nomad cowherd. In the *Bible,* the trauma localization is mentioned and its indirect mechanism is noted – «*…hip was dislocated…*» (Gen. 32:25) (23), as well as a certain injured anatomical element is referred to as *sinew* (Gen. 32:32) (23). The place where the trauma occurred is named as the Jabbok River (Gen. 32:22) (23) (sin. Nahr ez-Zerqa), near the Peniel settlement (Gen. 32:30-31; Judg. 8:8–9) (23), destroyed in the rule of King Gideon (Judg. 8:17) (23). An approximate time of the injury is known, too – the middle of the night (Gen. 32:22) (23), since before that Patriarch Jacob was sleeping (Gen. 32:21) (23), while after that he was resting «*till daybreak*» (Gen. 32:24) (23). The date of the event is mentioned in the *Book of Jubilees* as the ninth month, eleventh day of 2135 AM (31), (circa November 20, 1626 BC). Accordingly, Patriarch Jacob's age at the moment of the injury was about 87 years. The circumstances of the trauma are described in the *Bible:* in the conditions of limited visibility, Patriarch Jacob waded across the stream with a caravan containing children and animals (Gen. 32:7, 22) (23). That was a serious physical activity, with young children and animals being carried by Patriarch Jacob himself obviously (Gen. 32:22–23) (23).

The injury consequence is mentioned, as well – alteration of the walking function manifested as "*…limping because of his hip*" (Gen. 32:31) (23). It does not contradict the modern research, which states that LCF injury may cause pain, alter the gait and result in the coxarthrosis development (5–7). It is possible that the injured anatomical element was later verified morphologically, since, after Patriarch Jacob's death in Egypt, his son Joseph "*…directed the physicians in his service to embalm his father*" (Gen. 50:2) (23).

The Ancient Egyptian physicians' deep knowledge of anatomy is confirmed by the *Edwin Smith Surgical Papyrus* dated from XVII century BC, the first manuscript of the original author being possibly written as early as about 3000–2500 BC (35). Egyptian physicians used a general term "*mt*" (*met*) – "*cord-like connection*", to denote blood-vessels, ligaments, tendons, canals (bronchi), nerves, muscles and sinews (35). A circular cord shape is inherent for LCF, as well (36), that makes it possible to apply both the Egyptian *mt* and the Hebrew *gid* to it.

The anatomical knowledge in the Ancient Egypt had been obtained when performing eviscerating, embalming, dissection and from treatment of wounds (35). Taking into account the elementary level of medical technology, during that distant era physicians could not obviously distinguish between "*cord-like*" anatomical structures. We saw the hieroglyph *mt* in documents related to the rule of Pharaoh Thutmose III (37) and in the medical *Papyrus Ebers* (38). The age of the *Papyrus Ebers* (39) is the middle of XVI century BC (40), but it could have also been written between 4688 BC and 1552 BC (41). In the *Papyrus Ebers*, a real medical encyclopedia of the Ancient Egypt, the hieroglyph *mt* is used for denoting blood-vessels and nerves (42). E.A.Budge calls the same hieroglyph *mt* and translates it as vein, artery, at the same time the author denotes the words cord, band, *ligament* – with the hieroglyph *rutchu*, and *sinews* – with the hieroglyph *aakhkh* (43). The upper element of the hieroglyph *mt* resembles the Greek letter "λ" in its shape (**Figure 1**).

This letter is best suitable for description of branched anatomical structures – blood vessels, nerves, bronchi. It is also applicable for LCF, the proximal end of which may divide into several portions to attach to different (six!) points of the acetabulum (44). The upper element of the hieroglyph is also named *mt* and translated as phallus (45), or chief, governor, president, front, male, masculine, procreate (43). H.L.E.Lüring had pointed to the relation between the hieroglyph *mt* and the *Bible* in his dissertation, considering its Coptic analogues – ⲙⲟϯ, ⲙⲟⲩⲧ, ⲙⲟⲩϯ (46). Coptic is the final phase of the Egyptian language which had been used in Egypt for a thousand years from the first century AD (47) that allows its consideration when clarifying the meaning of hieroglyphs. In the *Pentateuch* in Coptic, we find that, in the 32nd verse of XXXII chapter of the book of *Genesis* the terms ⲏⲩⲙⲟⲩⲧ and ⲙⲡⲓⲙⲟⲩⲧ are used to denote LCF (48). In Latin they mean – collum, juncture, dorsum, vinculum and nervus (49) and may undoubtedly describe a similar structure, LCF.

The first description of a ligamentum capitis femoris injury

The study of the literature and geographic maps allows determining the coordinates of the most probable place of Patriarch Jacob's caravan crossing of the Jabbok River: 32.1722 N, 35.6193 E (Jordan). During our expedition following the way of Patriarch Jacob's caravan we visit-

Figure 1 Left. The oldest term for the notion ligament (Egyptian hieroglyph mt). The hieroglyph mt used in the Edwin Smith Surgical Papyrus, including the notation of ligaments; Plate XII, Line 1 (35).

Figure 1 Right. The oldest term for the notion ligament (Egyptian hieroglyph mt). The hieroglyph mt used in the Edwin Smith Surgical Papyrus, including the notation of ligaments; Plate V, Line 3 (35).

ed the most probable place of his crossing of the Jabbok River (**Figure 2**). At present time, there is a bridge between the cities of Dayr'Allah and Maʿaddi at that location, in our opinion, Patriarch Jacob followed that way to meet his brother Esau (Gen. 33:4) (23). The Jabbok River water is currently being actively used for agricultural purposes. Therefore, we observed a scant watercourse which only filled the riverbed up the highest depth line. When traveling to the place of the assumed river crossing, we noted that the Jabbok River has sloping banks, shallow and wide bed, ground bottom and a few boulders at the mentioned place, which makes it possible for small animals and humans to wade across the river.

The wading was evidently proceeding in a hurry and anxiety, since no one in the caravan knew about the intentions of the approaching army of Esau (Gen. 32.6–7, 20) (23). With insufficient illumination and a weight in his hands, Patriarch Jacob might very possibly stumble on a large wet boulder, temporarily lose his balance and even fall. In such moments, discoordination of the muscle activity is commonly observed. In this case, the hip is often adducted and the pelvis is inclined in the frontal plane for the balance stabilization. It is known that in the vertical position, with the opposite pelvis drop, LCF is stretched (7,50), since it is a passive restraint of the HJ adduction (5,7). Such a fast movement leads to a dramatic growth of the tensile stress in LCF. In the absence of an effort of the abductor muscle group, LCF appears the only element restraining the pelvis drop. In this case, the HJ functions as an analogue of a Class 2 lever (4,7), and the load onto LCF may be calculated from the formula:

$$PL = FL_1$$

where P – is the body weight (N);
L – is the load arm (m);
F – is the force of the LCF resistance (N);
L_1 – is the effort arm of the LCF resistance (m).

Figure 2. The place of Patriarch Jacob's caravan's crossing of the Jabbok River (earlier unknown hypothesis). The most probable place of Patriarch Jacob's caravan's crossing of the Jabbok River (sin. Nahr ez-Zerqa) (Gen. 32:22) (23)– (32.1722 N, 35.6193 E), on the left one can see the bridge and a part of Route N° 65 between the cities of Dayr 'Allah and Maʿaddi (Jordan, November, 2014).

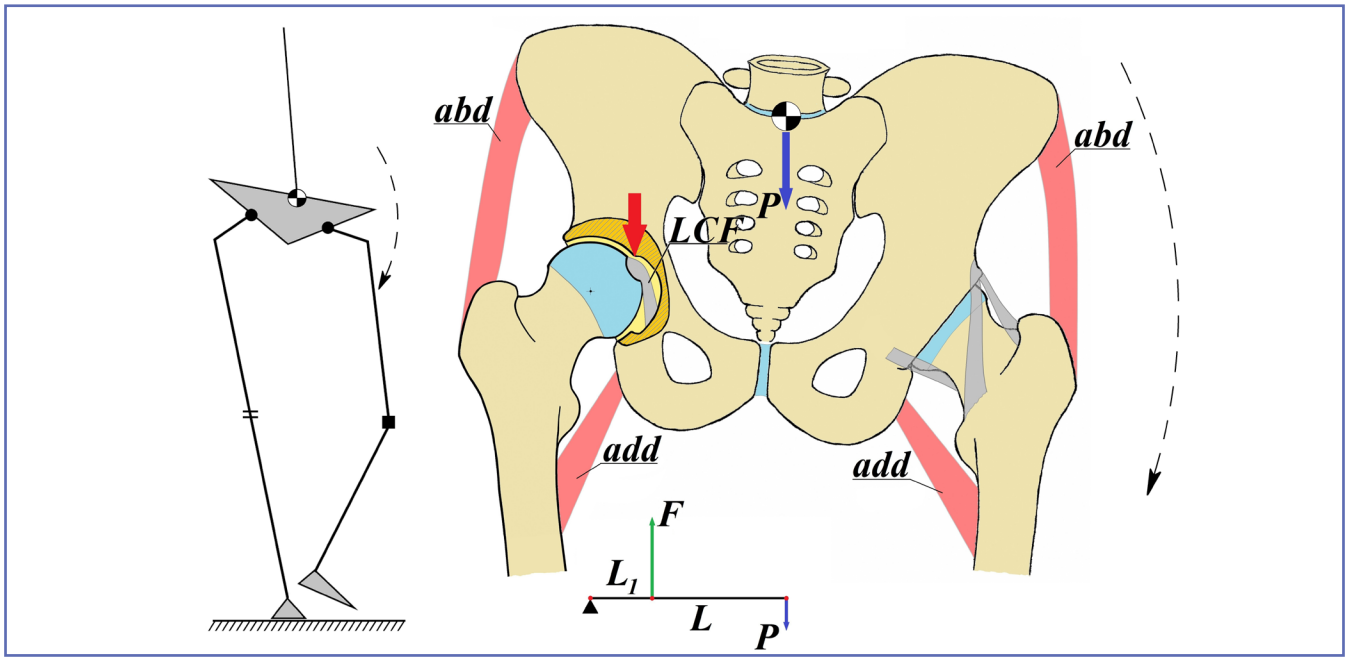

Figure 3. Pathogenesis of injury of the **LCF** during walking (schematically). Forced pelvis drop in the frontal plane and the hip adduction in the case of a sudden loss of balance in the single support stance and single support swinging. **Left** – general view of the position; **Right** – view of the pelvis with the removed anterior wall of the support HJ; **Bottom** – simplified scheme of the body balance conditions. Notations: **LCF** – ligamentum capitis femoris, **P** – body weight, **F** – force of the **LCF** resistance, **L** – load arm of the body, $\mathbf{L_1}$ – effort arm of the **LCF** resistance (the arm ratio is 1:3.1), **add** – adductor muscle group, **abd** – abductor muscle group, dashed arrows depict the direction of the pelvis rotation, thick solid arrow points to the interior edge of the semilunar surface, which may injure the distal end of LCF at the moment of the forced hip adduction and pelvis drop.

The load arm of the body weight exceeds the effort arm of the LCF resistance by approximately three times (**Figure 3**). Correspondingly, at a body mass of 70 kg, taking into account the 18% mass of the support leg and the load arm of the body equal to 0·1 m, the effort onto LCF will be 1704.6 N, that exceeds its most optimistic strength of 882±168 N (3).

Until the present time, it has been conventionally agreed upon that the HJ always functions similar to a Class 1 lever, while the pelvis in the single support orthostatic position is stabilized only with the abductor muscle group, and the load onto the femoral head acts predominantly from above (1,51). However, new experimental data have shown that LCF may participate in sustaining the unstrained single support orthostatic position and asymmetric double support orthostatic position (4,7). The simultaneous LCF strain and the abductor muscle group stress provide the pelvis stabilization in three planes at the same time and also provide a uniform load of both the upper and lower sectors of the femoral head (4,7).

We believe that such an effort, which arose as a result of the forced rotation in HJ, could lead to the injury of LCF Patriarch Jacob. His LCF might have been torn, or amputated, as if with a guillotine, in the case of a contact of its distal end with the edge of the *facies lunata*. Not only the hip adduction, but also rotation in the HJ in the horizontal plane may result in LCF amputation. We observed a partial LCF amputation after HJ supination in a patient with fractured pelvic bones (**Figure 4**). The presented illustration demonstrates a possibility of LCF injury from excessive supination in HJ. Positioned between movable bones – the femoral head and the pelvis, LCF resembles a ship facing a risk of sailing between the mythical Symplegades. We may exclude HJ dislocation in Patriarch Jacob, since after dislocation a man immediately loses his ability to walk. The term "יקע" describing Patriarch Jacob's injury (Ber. 32:26) (24) is translated from Hebrew as "he was out of Joint, separated, alienated" (25).

The first author to tell about a ligamentum capitis femoris

According to our hypothesis, Patriarch Jacob did not notice the LCF injury right away, absorbed by the river

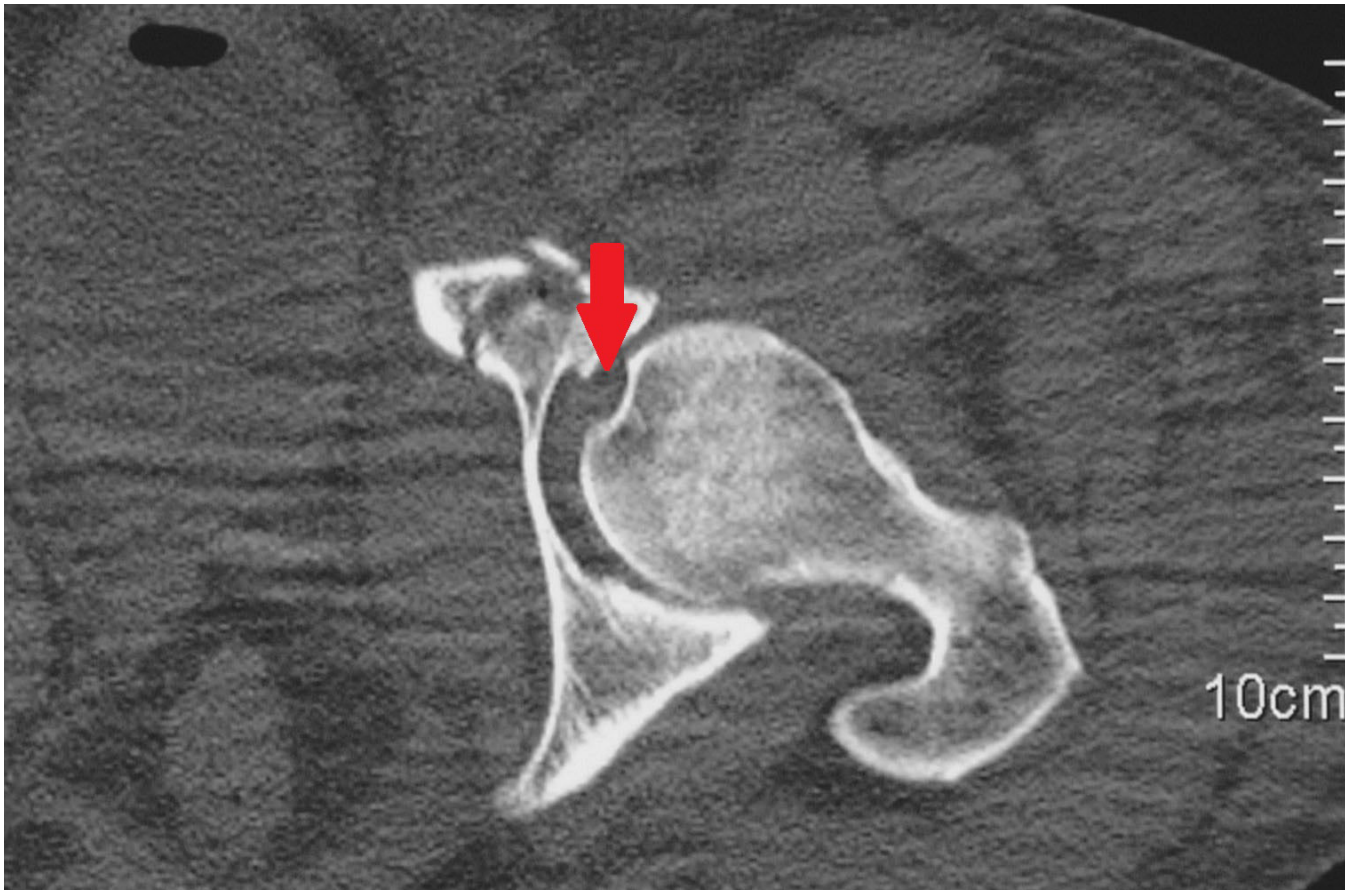

Figure 4. X-ray symptom of injury of the LCF (earlier not described). CT scan of a man, J.H., middle age, with a fracture of the pelvis, which we happened to observe at the Medizinische Hochschule Hannover (2003); on the left, HJ is intact, with the fovea capitis femoris, the distal region of LCF attachment, being within the borders of the fovea of the acetabulum; on the right, a greater angle of supination is seen in the injured HJ, as well as the fact that the fovea capitis femoris by ½ penetrates beyond the limits of the anterior sector of the facies lunata of the acetabulum, the sharp interior edge of the facies lunata incising the distal LCF end.

crossing and the thoughts about the upcoming meeting with his brother. After such injuries, a hemorrhage occurs into the joint cavity, the intraarticular pressure rises, which is felt as pain. The pain, fatigue and emotional stress led to a restless sleep of Patriarch Jacob, during the rapid eye movement phase (51) of which he subjectively "*struggled with the angel*" (Hos. 12:2–4) (23). In this virtual encounter (Gen. 32:24) (239), the pain from the injury at the river crossing mixed in Patriarch Jacob's mind with the "*fight*" (Gen. 32:28) (23) for the father's blessing (Gen. 27:25–29) (23) and the birthright (Gen. 25:31–34) (23). The story told by Patriarch Jacob about the events at the Jabbok River (Gen. 32:13–32) (23) may have initially been written in the Egyptian hieroglyphic writing (Gen. 48:20) (23) by one of Joseph's sons, Manasseh or Ephraim, after his death in 2242 AM (31) (circa 1518 BC). In that text, LCF might have been called *mt*, similarly to the Hebrew word *gid*, since both the terms were applied in respect to anatomical elements close in their appearance (30,35). The coincidence of the age of the *Edwin Smith Surgical Papyrus* (XVII century BC) (35) and the time period of Patriarch Jacob's life 2046–2188 AM (31) (circa 1714–1577 BC), testify to the validity of this viewpoint.

Joseph was the second after the pharaoh (Gen. 50:40) (23), and "*Potipher priest of On*" (Heliopolis) was his father-in-law (Gen. 41:42) (23). Accordingly, Joseph's children, Manasseh and Ephraim, grew up in privileged conditions, must have been taught Egyptian literacy and have possibly had some medical knowledge. Long before the described events, the high priest of Heliopolis was Imhotep (52),

the historical Father of Medicine (54), a prototype to the medicine-related gods: Asclepias (55), Apollo, Panacea, Hygeia (56). Imhotep the great architect-physician lived in the Third Dynasty of the Ancient Egypt (57). The time period of his life is not known reliably and dated in the broad limits anywhere from 3500 (54) to 2686 BC (58). By one of the hypotheses, it was Imhotep who authored the *Edwin Smith Surgical Papyrus (*35). These facts additionally testify to the validity of our viewpoint on the authorship of the book of *Bereshit*, which belongs to one of Joseph's sons, most probably, to Ephraim, who received Patriarch Jacob's blessing (Gen. 48:14) (23). The mentioned dates, names and the reality of the events described in the book of *Bereshit* as such may be criticized. The authors of the book of *Bereshit* had most probably learned about LCF and its importance for realization of the normal walking from either physicians or priests of the Ancient Egypt.

CONCLUSION

The first description of the ligamentum capitis femoris in the medical text is given by Hippocrates of Kos in the treatise *Instruments of Reductions* (V-IV century BC). According to our hypothesis, the first in the history of mankind to mention a ligamentum capitis femoris, is contained in the ancient literary monument of *Torah* (XII-II century BC), there it is first reported about its damage, which led to disruption of walk biomechanics. We believed that a LCF injury may disrupt the walking function, has been known since XII–II century BC, and, probably, since XVI century BC. The analysis of the events described in the book of *Bereshit*, based on the modern medicine view, allows a better understanding the LCF importance for locomotion. Accurate knowledge of its role in the musculoskeletal system will provide a more precise of understanding the HJ diseases pathogenesis, will aid in development of novel approaches to distant diagnostics of its pathology.

NOTE

The conversion of the Hebrew calendar dates into the Gregorian calendar dates was performed using an Internet-shared converter (59). When converting the dates, we accepted that the year mentioned in a primary source falls on the first day of the month of Nisan. During the events described in the book of *Bereshit*, the Gregorian calendar did not exist yet, therefore, the dates, obtained in the Gregorian chronology, are approximate.

Conflict of Interest

The authors declare that they have no conflict of interest.

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