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XIV

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Здоровье — основа человеческого потенциала: проблемы и пути их решения. 2019. Т.14, часть 1. 504 с.

В книге опубликованы тексты докладов и статьи, отражающие уровень и динамику заболеваемости и смертности по основным группам заболеваний среди населения. Приводятся сведения о демографических процессах в нашей стране и за рубежом с учетом социально-экономических и экологических аспектов. Поднимаются проблемы школьного и высшего образования, психологии, педагогики, социологии, философии и истории медицины и здравоохранения. Освещаются вопросы продовольственной безопасности. Предлагаются пути улучшения здоровья народа в стране и ее отдельных регионах, городах и учреждениях.

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Организация Объединенных Наций

Всеобщая Декларация прав человека

(Принята резолюцией 217 A(III) Генеральной Ассамблеи ООН от 10.12.1948 г.)

В Преамбуле к Декларации сказано: *принимая во внимание*, что необходимо, чтобы права человека охранялись властью закона в целях обеспечения того, чтобы человек не был вынужден прибегать, в качестве последнего средства, к восстанию против тирании и угнетения.

Статья 1. Все люди рождаются свободными и равными в своем достоинстве и правах. Они наделены разумом и совестью и должны поступать в отношении друг друга в духе братства.

Статья 19. Каждый человек имеет право на свободу убеждений и на свободное выражение их; это право включает свободу беспрепятственно придерживаться своих убеждений и свободу искать, получать и распространять информацию и идеи любыми средствами и независимо от государственных границ.

Статья 23.3. Каждый работающий имеет право на справедливое и удовлетворительное вознаграждение, обеспечивающее достойное человека существование для него самого и его семьи, и дополняемое, при необходимости, другими средствами социального обеспечения.

Статья 25.1. Каждый человек имеет право на такой жизненный уровень, включая пищу, одежду, жилище, медицинский уход и необходимое социальное обслуживание, который требуется для поддержания здоровья и благосостояния его самого и его семьи, и право на обеспечение на случай безработицы, болезни, инвалидности, вдовства, наступления старости или иного случая утраты средств к существованию по не зависящим от него обстоятельствам.

Организация Объединенных Наций

Universal Declaration of Human Rights

(Adopted by Resolution 217 A (III) of the United Nations General Assembly on 10.12.1948)

The Preamble to the Declaration states that it is essential that human rights should be protected by the rule of law, in order to ensure that man is not to be compelled to have recourse, as a last resort, to rebellion against tyranny and oppression.

Article 1. All human beings are born free and equal in dignity and rights. They are endowed with reason and conscience and should act towards one another in a spirit of brotherhood.

Article 19. Everyone has the right to freedom of opinion and expression; this right includes the freedom to hold opinions without interference and to seek, receive and impart information and ideas through any media and regardless of frontiers.

Article 23.3. Everyone who works has the right to just and favourable remuneration ensuring for himself and his family an existence worthy of human dignity, and supplemented, if necessary, by other means of social protection.

Article 25.1. Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care and necessary social services, and the right to security in the event of unemployment, illness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control.

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К 170-летию Ивана Петровича Павлова – выдающегося русского российского
исследователя в области физиологии, первого нобелевского лауреата России.*

*"The conference is dedicated to the 185th anniversary of the great Russian scientist and citizen of Russia -
Dmitry Ivanovich MENDELEEV, and the 150th anniversary of his main legacy,
the Periodic Law for Chemical Elements;
and to the 170th anniversary of **Ivan Petrovich PAVLOV -** the outstanding
Russian physiologist and the first Nobel Prize laureate from Russia".*

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ANATOMICAL OBSERVATIONS ON THE INCONGRUENCES OF THE ARTICULAR SURFACES OF THE PROXIMAL INTERPHALANGEAL (P.I.P.) JOINT IN THE NORMAL HUMAN FINGER

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Summary

By plane geometry graphical constructions, applied on a two-dimensional High Resolution MRI sagittal slice of the proximal interphalangeal (P.I.P.-) joint of an anatomical specimen of the normal human finger, the incongruences of the mating joint surfaces were quantified. Our outcome data offer better insights and may be useful for novel PIP prostheses development.

Keywords *PIP-joint; articular surfaces; graphical analysis; PIP-arthroplasty*

Introduction

In the past decade, various reports were published containing qualitative and quantitative data on osteoarthritis (OA) and rheumatoid arthritis (RA) in Russian communities [1] as well as in the Russian Federation [2-3]. These chronic diseases can be characterised as follows. “Osteoarthritis is a degenerative joint disease, that changes the tissue homeostasis of articular cartilage and subchondral bone. … The common features of osteoarthritis are loss of cartilage, joint space narrowing, hypertrophic bone changes, osteophyte formation, osteophytes defined as outgrowth of the bone and cartilage occurring at the joint margins” [4]. “Rheumatoid arthritis is a chronic, destructive, inflammatory disease of the synovial membrane that lines … the surface of joints, where it produces lubricating and nourishing synovial fluid” [5]. In the Russian Federation, not only the physical health problems, but also the social burden and the discomfort of OA and RA have been reported [6], [7].

State of the art

To overcome the debilitating effects caused by OA and RA, such as pain, loss of function, and deformations of the interphalangeal joints, during the past decades prostheses of these joints were developed and applied, especially Proximal Inter Phalangeal (PIP) prostheses, also known as PIP-implant arthroplasties. In the wake of this, a wealth of clinical and epidemiological reports on their higher or lower success rates followed, e.g. [8], [9], [10], [11]. Anatomically, the PIP-joint of the human finger is composed by the convex caput (or head) of the proximal phalanx articulating with the concave basis (or base) of the middle phalanx (Fig. 1a, Fig. 1b). Meanwhile, the development of any novel PIP-prosthesis (or implant arthroplasty) greatly depends on *in situ* measurements in anatomical specimens of the normal human finger. In general, with the only exception of [12] and [13], measurement data on PIP-arthroplasty *design* remain remarkably scarce. In [13], an alternative concept of a *rolling-without-sliding* PIP-arthroplasty is presented, in a certain way foreshadowed by [14], while the concept of [12] is mainly based on circle-like shapes, which in fact are not so realistic anatomically. In view of all this, is is justified to provide some more data on the morphology of the proximal convex part, as well as of the distal concave part, of the PIP-joint of the normal human finger *in situ.* Therefore, the plane geometrical properties of the curvatures of both parts, also in relation to each other, are subject of this study.

Stating the problem

"The phalangeal condyles have the particularity of displaying a radius of curvature with an almost perfect regularity. This character clearly differentiates it from the femoral condyles (in the knee) that we always take as an example. In fact, the geometric location of the axis of flexion-extension movements of the second phalanx on the first phalanx…can be roughly considered as a single constant and fixed transverse axis" [15]. Indeed, comparing the proximal interphalangeal (PIP) joint (Fig. 1a) with the femoral condyles and the articulating surfaces of the tibia in the knee joint [16] makes clear such differences. Meanwhile, not only the knee joint, but also the PIP-joint of the finger have incongruent contact surfaces. Moreover, in anatomy, 'incongruent' is defined as "not agreeing in conformation; as, *incongruent* surfaces of a joint" [17]. One glance at the osseous outlines of the normal PIP-joint (Figs. 1a and 1b) is enough to note that the concavity of the distal segment, and the convexity of the proximal segment, do not match perfectly, in other words, they are incongruent. As a consequence, dorsal and palmar gaps between their bony surfaces can be observed (Fig. 1b, red arrows). In the *in situ* anatomical specimen of the human finger, however, wedge-shaped synovial folds - at least partly - compensate for such incongruences of the mating surfaces [18].

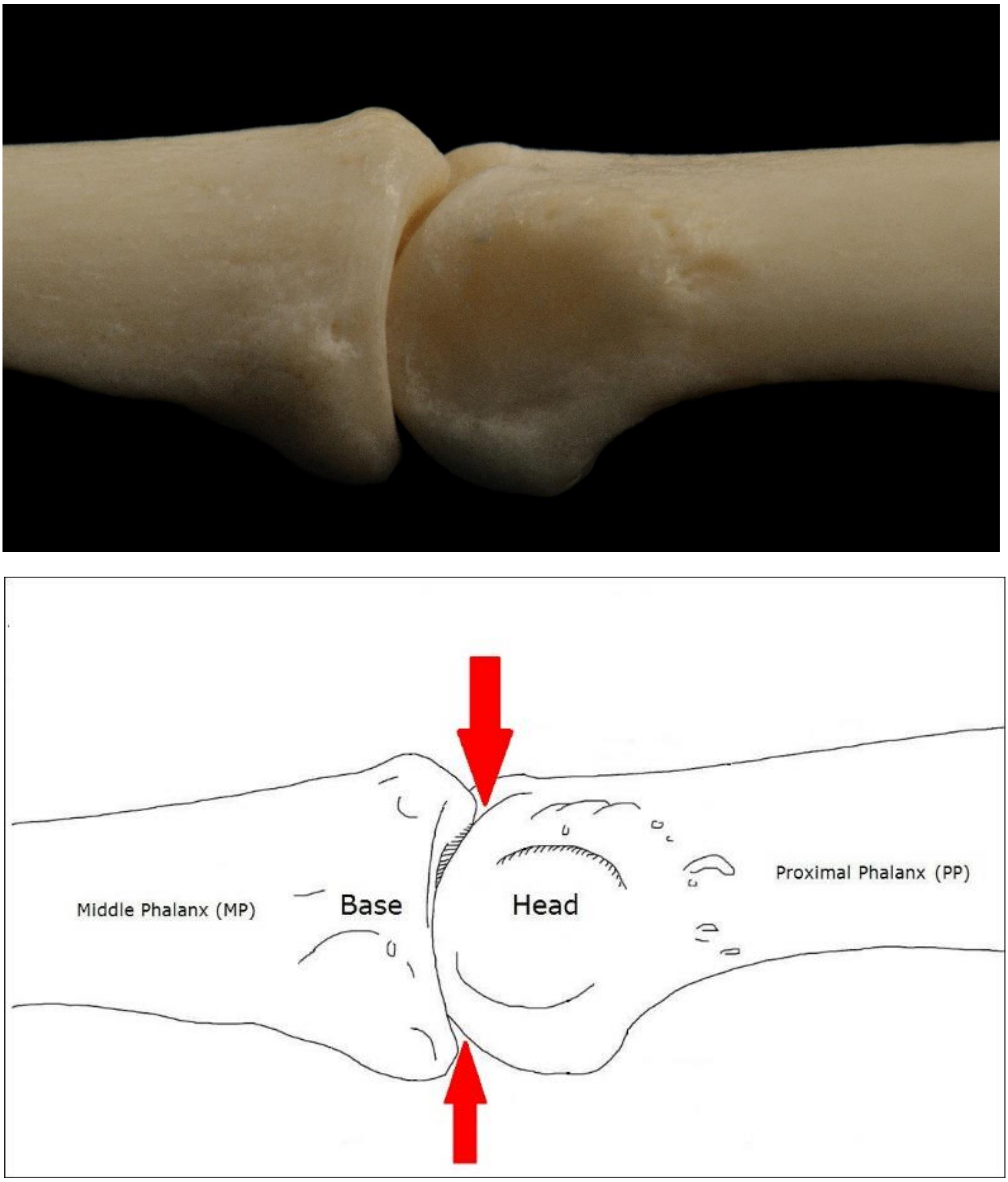
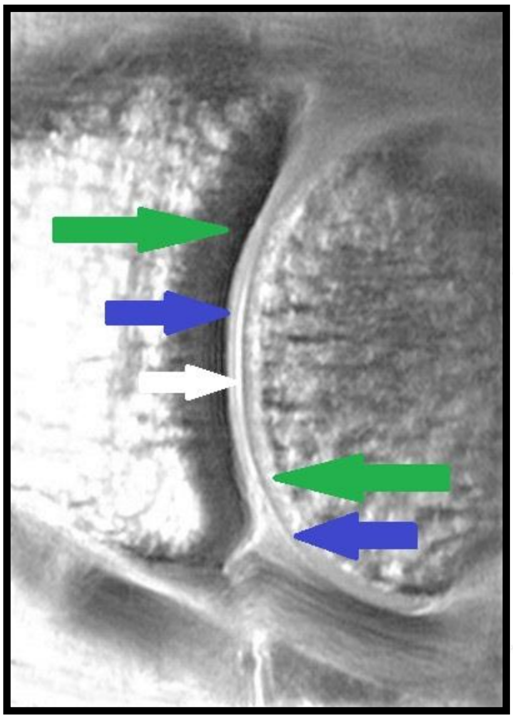


Fig. 1 a (top). Osteology of the proximal interphalangeal (PIP-) joint of an otherwise normal second finger, radial view. Left is distal; right is proximal. Fig. 1 b (bottom). Line drawing of Fig. 1a. Arrows indicate “gaps” of joint.

Material and methods

As the present study intends to assess the plane geometrical curvatures of the *in situ* articular surfaces of the concave distal segment, as well as of the "perfectly regular" [15] convex proximal segment, in one and the same PIP-joint of an anatomical specimen of the finger, we made use of archive pictural material, part of which had been already published [18], [19]. As a consequence, we are able to present real high resolution images, instead of the usual line diagrams of these curvatures [20]. Technical data are as follows. High Resolution-MRI (HR-MRI) of an otherwise normal human anatomical specimen of an extended right third finger was performed. Technical data of HR-MRI: Varian 400 spectrometer, 9,4 T superconducting magnet. Field of view FOV (mm) in transverse plane: 25 x 25; imaging data matrix of 350 x 350; pixel resolution (μm) 71 x 71. Further acquisition parameters: repetition time TR: 2500 ms; echo time TE: 18 ms; number of averages NA = 24; slice thickness 2 mm. One sagittal slice of the PIP-joint was used (Fig. 2a), meeting requirements normally posed by plane geometry.



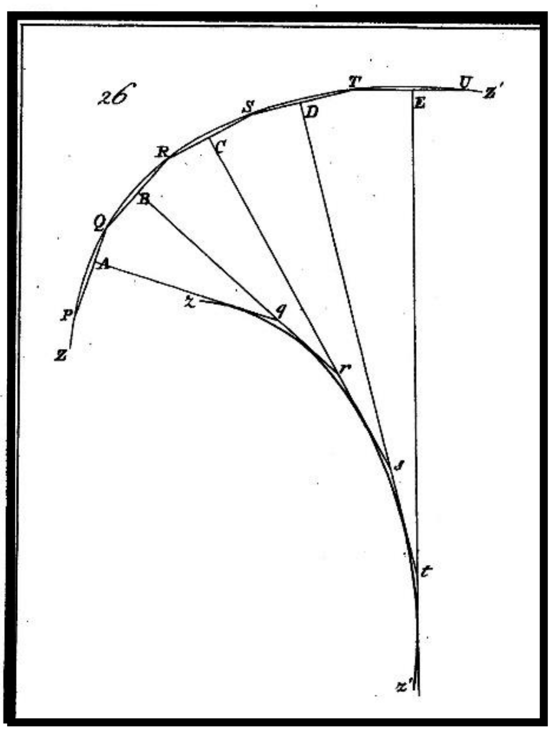
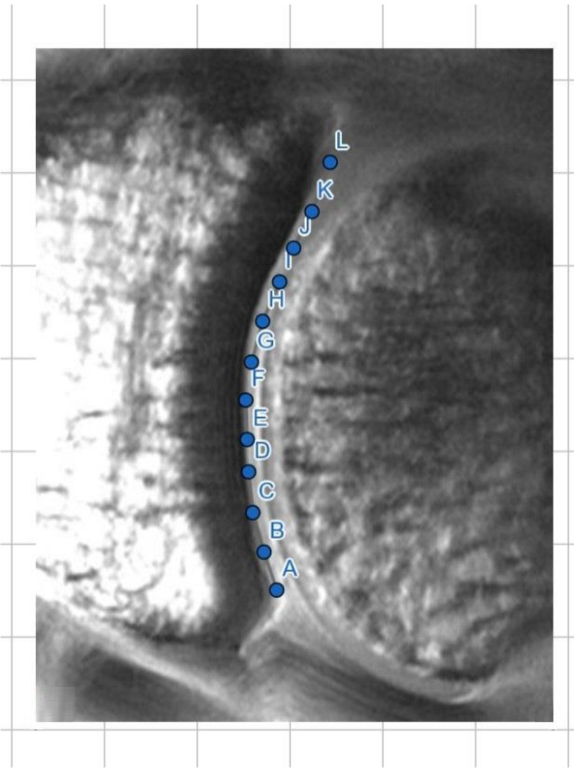


Fig. 2 a (left). HR-MRI sagittal slice of PIP-joint (see text), showing curvatures (left to right) of the distal segment, and of the proximal segment. Arrows in green: bone cortex; - blue: hyaline cartilage; - white: synovial fluid

Fig. 2 b (right). Approximate radii of a curvature can be found through the perpendicular bisectors of inscribed open polygon formed by its successive chords

Fig. 2a shows one resulting sagittal slice of the PIP-joint, including the curvatures (from left to right) of the distal segment, and of the proximal segment. According to a classical method in plane geometry [21], approximate radii of a curvature can be found through the perpendicular bisectors of an inscribed open polygon formed by its successive chords (Fig. 2b, facsimile of original [21]).



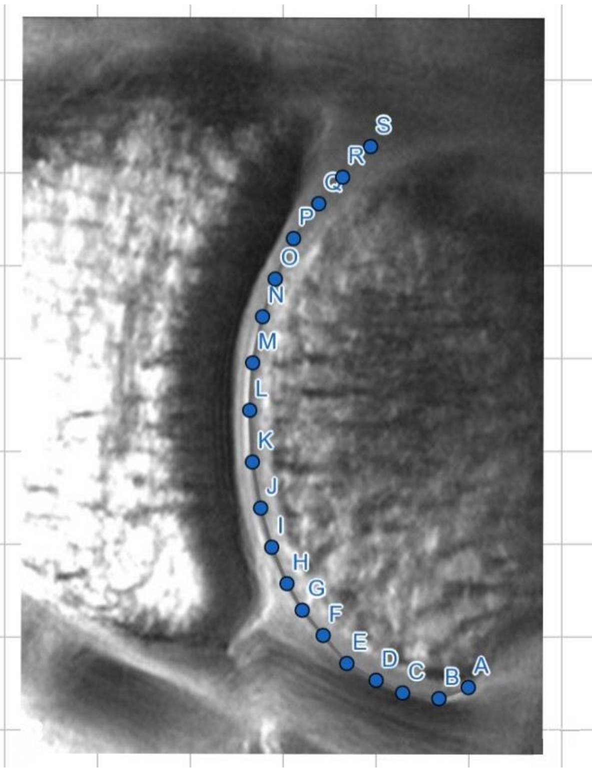
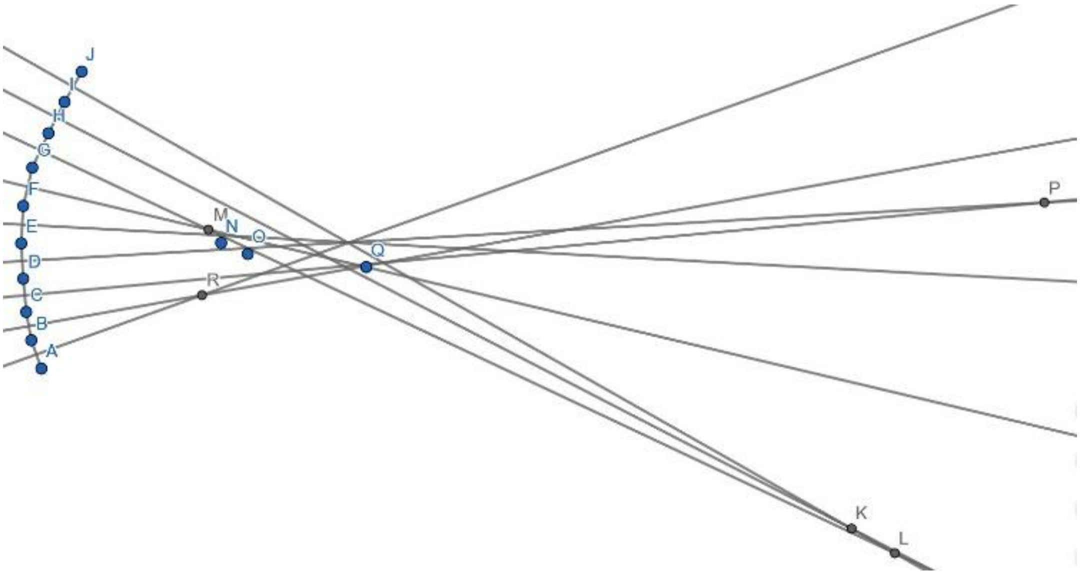


Fig. 3 a (left). Inscribed polygon A-L, plotted in order to approximate the concave curvature of the distal part of the PIP-joint, derived from Fig. 2a.

Fig. 3 b (right). Inscribed polygon A-S, plotted in order to approximate the convex curvature of the proximal part of the PIP-joint, derived from Fig. 2a.

In Fig. 3, these chords are plotted on the HR-MRI-slice, resulting in the shorter open polygon A-L of the distal curvature (Fig. 3a) and the longer open polygon A-S of the proximal curvature (Fig. 3b). With the mathematical computer graphics method [22], we graphically constructed the perpendicular bisectors of the chords of both curvatures, with the exception of chords JK and KL of the distal curvature that are convex instead of concave, as already suggested by the upper red arrow in Fig. 1b.



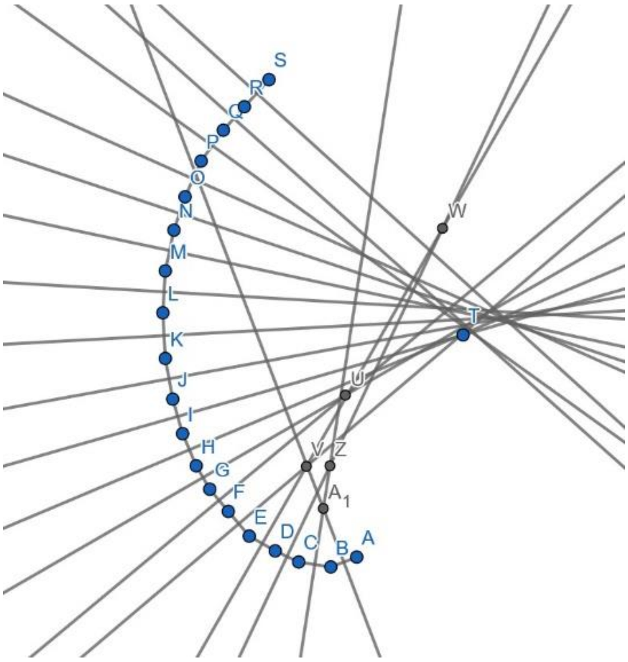


Fig. 4 a (top). Open polygon A-J (Fig. 3a) approximating the concave curvature of the distal part of the PIP-joint, used to graphically construct (see text) perpendicular bisectors of its chords, resulting in intersection points K-R.

Fig. 4 b (bottom). Open polygon A-S (Fig. 3b) approximating the convex curvature of the proximal part of the PIP-joint, used to graphically construct (see text) perpendicular bisectors of its chords, resulting in intersection points T-A_1.

Fig. 4a and Fig. 4b show the resulting geometrical constructions, by means of chord approximations of both original curves, as well as the intersection points of any pair of their successive perpendicular bisectors. As far as our computer program [22] allowed, most points of intersection were consecutively marked by successive lettering, namely K-R for the shorter concave distal curvature, and T-Z-A_1 for the longer convex proximal curvature (Fig. 4a and Fig. 4b).

Results

1. Distal curvature (concave)

The majority of points of intersection M through R of each pair of successive perpendicular bisectors of the chords, namely the points M, N, O, Q, and R, appears to be clustered (Fig. 4a). Other such clusters are not observed.

2. Proximal curvature (convex)

Roughly, two clusters of points of intersection of each pair of successive perpendicular bisectors of the chords can be noted (Fig. 4b). One cluster is located in the vicinity of point T. As our computer program [22] did not allow to insert an even finer and denser lettering, “T” alone stands for this cluster that represents some 10 successive points of intersection. Of the remaining successive points of intersection, the points U, V, Z, and A_1, located in more distal and more palmar positions than “T”, represent the second cluster.

3. Comparing both curvatures

When both graphical constructions are compared with each other, by representing them in one image (Fig. 5) at the same scale (as indicated by bold vertical bars **I** in Fig. 5), obvious differences between the two curvatures become apparent. Most of the radii of the distal (concave) curvature, starting from the cluster “M, N, O, Q, and R” are shorter than most of the radii of the proximal (convex) curvature, starting from the cluster around point “T”. This difference is indicated schematically in Fig. 5 by comparing the shorter line segment GH (Fig. 5, above) with the longer line segment IJ (Fig. 5, below). Radii of the rest of the proximal (convex) curvature, however, departing from cluster “U, V, Z, and A_1”, are much shorter than the line segment GH. In other words, in the extended PIP joint (that is to say, in the situation from where our analysis started) most of the distal curvature is too concave in relation to the convexity of the proximal curvature. In 90° flexion of the PIP-joint, however, the remaining (palmar) part of the proximal curvature is too convex in relation to the concavity of the distal curvature. Fig. 6b gives a model-wise approximation of the latter remarkable situation.

Our graphical plane geometry construction results (Fig.4) finally suggest that a) the distal curvature’s cluster of points shows rather equal radii of curvature of the involved area, and thus approximates the center of one circle;

b) the proximal cluster around point "T" represents in even better approximation the center of another circle; and c) points "U, V, Z, and A_1" lie by approximation on the evolute of their more palmar curvature.

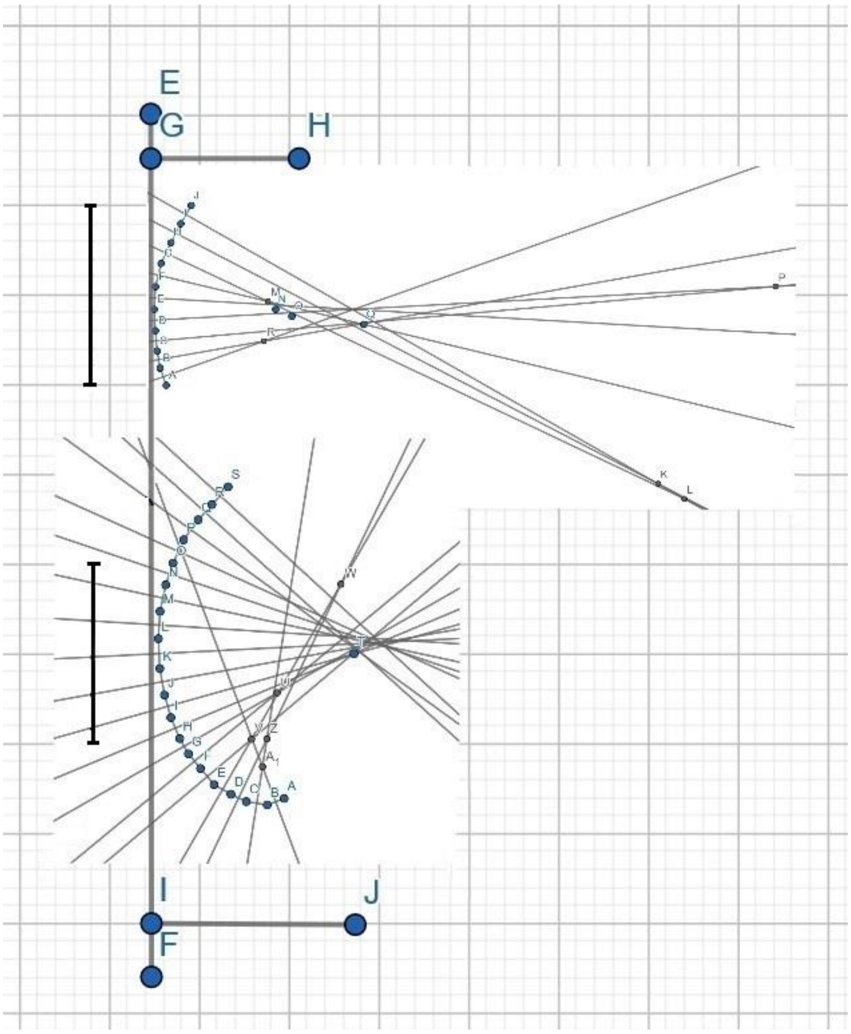


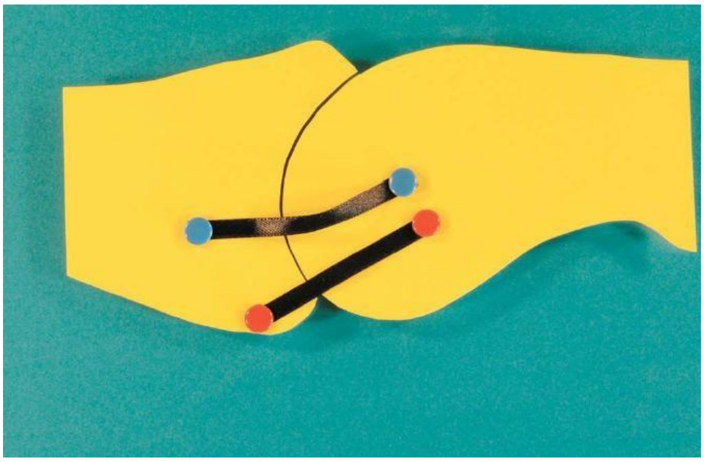
Fig. 5. Presenting both constructions Fig. 4a (above, concave curvature of distal part of PIP-joint) and Fig 4b (below, convex curvature of proximal part of PIP-joint) at the same scale (see text), shows quantitative differences between the clusters of points of intersection of their respective perpendicular bisectors.

Discussion

Our plane geometry graphic constructions, based on HR-imaging of a normal PIP-joint of the finger revealed - by approximation - separate clusters of centers of the curvatures of the distal concave part, as well as of the proximal convex part of this joint, and their radii. Starting with the convex curvature (Fig. 4b), correspondence of our cluster around "T" exists, with the gross general statement in [15] and with the refined findings of [23], produced much later than [15] and with the help of highly advanced technical methods.

However, in [23] and also in [24], such methods are applied mainly to define *kinematical axes* of flexion and extension of the PIP-joint. Only [25] analyses the *curvatures* - be it in the *distal* inter phalangeal (DIP-) joint of the finger.

With respect to our Results (3), model-wise two-dimensional representations of the PIP-joint in extension (Fig. 6a) show, that even with 'ideally matching' distal and proximal curvatures, flexion of this joint (Fig. 6b) will result in the palmar proximal curvature being *too convex* in relation to the distal curvature



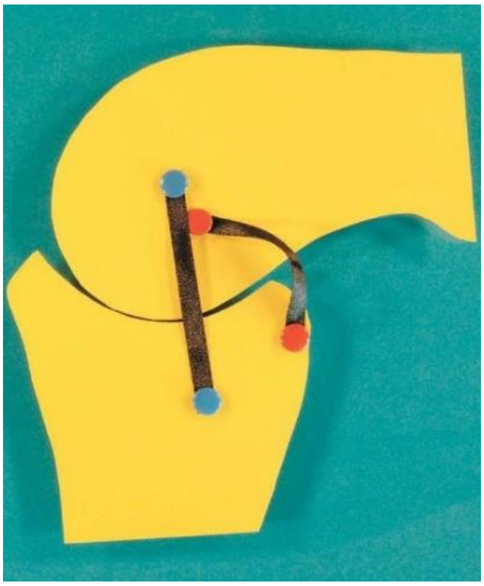
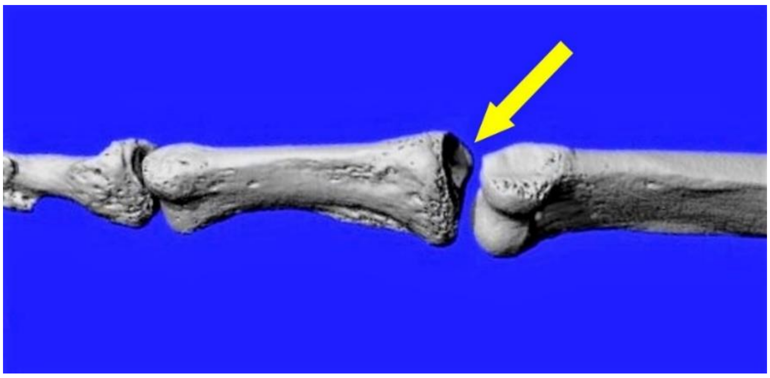


Fig. 6 a (left). Model of extended PIP-joint [18]; blue dots: proper collateral ligament attachments; red dots: accessory collateral ligament attachments. Fig. 6 b (right). In spite of these "ideal" congruencies in extension (Fig. 5a), PIP-flexion causes proximal curvature to be too convex for distal curvature.



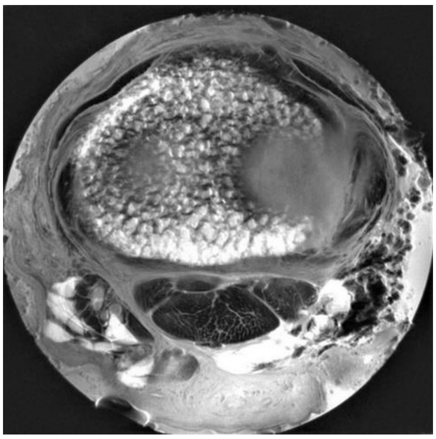


Fig. 7 a (left). Osseous outline of extended interphalangeal joints, exploded view. Arrow indicates impression of proximal curvature in distal curvature. Fig. 7 b (right). PIP-joint, transverse HR-MRI [26]: impressions are visible.

Corresponding well with our Results (3.), [27] notes a certain "suction cup effect", thus stabilising the PIP-joint in full extension, also thanks to the synovial fluid layer squeezed between resilient hyaline cartilage layers, that cover the joint surfaces. This phenomenon leaves some 'impressions' in the concave curvature (Fig. 7). These layers display themselves as *white* and *slightly grey* crescents respectively, halfway the HR-MRI (Fig. 2a, arrows). Concerning the PIP-joint in flexion, [24] describes comparable phenomena, and also notes that the 'center of rotation' shifts in distal and palmar direction.

Conclusion

In the proximal interphalangeal (PIP-) joint of the human finger, the incongruences of articular surfaces of its distal part (base of middle phalanx), and proximal part (head of proximal phalanx), quantified by plane geometry, are based on different, separate centers of curvatures, and radii of curvatures.

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