

PATTERNS OF SUBCHONDRAL MINERALIZATION OF THE METACARPOPHALANGEAL JOINT OF THE THUMB

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The decisive relevance of the metacarpophalangeal joint (MPJ) of the thumb is obvious in respect of the need for the grip functions of the hand particularly regarding different kinds of sport. Surprisingly, there is a lack of information especially about the functional morphology of this joint. Based on CT osteoabsorptiometry (CT-OAM) 10 MPJs aged 52-90 years were investigated and mineralization patterns from the subchondral bone plates assessed. It was shown that the mineralization was higher in the phalangeal part than in the metacarpal one. While the maximum of mineralization lied in the phalangeal plate near the dorsal border in the metacarpal plate it was located more centrally. It was concluded that under high load the contact area also was oriented close to the dorsal joint part. This could be explained by the particular kinematics of this joint. Furthermore, a displacement of the resultant during the end phase of movements could be made responsible for this morphologic reaction.

Key-words: Metacarpophalangeal joint, thumb, subchondral mineralization, 3-D image reconstruction, joint pathology, biomechanics

The metacarpophalangeal joint (MPJ) of the thumb is of indisputable importance for the grip function of the hand and through this for the rich spectrum of labour activities. The active participation of this joint in exercising a number of sports such as volleyball, basketball, etc. correlates with the high traumatic risk (1). In this respect, it is of interest for the orthopaedic practice and sports medicine. The prevalent number of studies in the literature is

dealing with damages of the joint and surgical techniques on one hand and instrumental methods on the other (4) but the amount of reports about its morphology and functional interpretation is limited.

Advancing in years, an essential place in the joint pathology is taken by the leading to functional damages and degenerative alterations for whose appearance the factors of mechanical origin should be considered. The development of an idea connected with the mechanical loading is of decisive importance for understanding the case of thumb MPJ. **Based** on the studies of

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Knief (2) and Mueller-Gerbl et al. (3) the distribution of the subchondral mineralization appears to be the most substantial morphologic parameter reflecting the long-term acting joint stress. Its noninvasive determination is possible with the help of the CT osteoabsorptiometry (CT-OAM) method invented by Mueller-Gerbl et al. (3).

The purpose of this investigation is to define the patterns of subchondral bone density of the MPJ since it has never been examined in that aspect at all.

MATERIAL AND METHODS

Sagittal CT-sections with thickness of 1 mm were prepared from 10 anatomical specimens of MPJ of the thumb (age 52-90 years). Then a macroscopic observation was made looking for cartilage lesions. Using the CT-OAM method the sections were treated in a certain sequence. First a 3-D reconstruction of the articulating bones *Os metacarpale* and *Phalanx proximalis* was conducted. An isolation of the subchondral bone of every section and a 3-D reconstruction of the joint surfaces followed, and the bone density was depicted in different shades of the grey colour. The achievement of coloured picture of the joint surface was obtained by the use of colours, each one of them corresponding to a definite level of bone density. The last stage of the computer processing was the pro-

jection of the coloured image of the joint surfaces above the 3-D portrayal of the articulating bones. A scheme subdividing the joint surfaces into 9 zones was prepared to make the interpretation of the subchondral mineralization easier.

RESULTS AND DISCUSSION

The study revealed that the density maxima of *Phalanx proximalis* were located mainly in the dorsal and dorso-radial zones of the joint surface. Areas with very low degree of mineralization were found in the centro-ulnar and palmo-ulnar regions. Density maxima of the *Os metacarpale* were chiefly situated in the centre of the joint surface. The other observed type of distribution was called polymorphic and it was characterized by the maxima in different zones of the joint surface. The comparison between the density patterns of the joint surfaces revealed higher grade of mineralization of the *Basis phalangis proximalis*. Relative symmetry between the left and the right joint surfaces was established.

The macroscopic observation of the joint surfaces displayed the presence of lesions of the joint cartilage located in the radial 1/3 of the *Caput ossis metacarpalis*, and in the dorso-radial 1/3 of the *Basis phalangis proximalis*. The subchondral bone was characterized by different degrees of density in every zone of the joint surfaces in conformity with the loads acting on them. The CT-

OAM method used for determining the subchondral mineralization provides an opportunity for making conclusions about the mechanical situation of the joint. The patterns of distribution of the subchondral bone density depend on the biomechanics, the geometry, and the size of the joint bodies. The *Basis phalangis proximalis* subjected to greater loads mainly carried by the dorsal zone, which correlates with density maximum located there, reveals higher degrees of mineralization compared to the *Caput ossis metacarpalis*. The centrally located density maximum of the *Caput ossis metacarpalis* is in conformity with the more strongly expressed convexity in the central region of the surface. The polymorphic type of density distribution is interpreted as a result of the flatter joint surface. The specificity of the distribution of the

mineralization is connected with the differences in the size of the convex and the concave joint surfaces. The density distribution of the *Basis phalangis proximalis* reveals that the contact area is smaller. The cartilage lesions in the radial and dorso-radial regions correlate with the established there small zones of density maxima.

One possible explanation of the degenerative changes in these places could be nonphysiological distribution of the load carried by small joint areas, whose sizes are not adequate to the conducted stress and thus become the first zones with degenerative cartilage alterations. The investigation of the subchondral bone density of thumb MPJ with the CT-OAM method would be useful in a diagnostic aspect with mechanically determined joint pathology.

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Модели на разпределение на субхондралната костна тъкан на дланно-фалангеалната става на палеца

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Дланно-фалангеалната става на палеца е от безспорно значение за хватателната функция на ръката и чрез това - за осъществяване на разнообразния спектър от трудови дейности и спортове, като рискът от травми е относително висок. В този смисъл ставата представлява интерес за ортопедичната практика и спортната медицина. Субхондралната костна плътност е параметър, отразяващ натоварването на ставните повърхности, и е установим посредством метода на КТ-остеоабсорбиометрия. От 10 анатомични препарата на дланно-фалангеалната става на палеца бяха подготвени сагитални КТ-срезове с дебелина 1 mm, на базата на които след компютърна обработка на данните бе постигнато цветно изображение на разпределението на субхондралната минерализация. Резултатите показват наличие на максимални нива на плътността за ставната повърхност на проксималната фаланга в областта на дорзалната трета. Участъците с висока плътност за os metacarpale са локализирани предимно в центъра на ставната повърхност. Основата на проксималната фаланга показва по-висока степен на минерализация, доказваща по-голямото натоварване, на което е подложена.