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HANDLING THE PC MOUSE, AND OUR SMALL FINGER JOINTS

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Abstract

This study offers data on finger joint morphology, revealed by micro-anatomical observations, histological screening, and various high resolution imaging techniques in in-vitro anatomical specimens of small finger joints. Such data may help to understand the use of finger joints while handling PC mice, especially flexing and extending the fingers in e.g. moving a PC mouse scrolling wheel during educational and professional activities. Possible solutions after long standing finger problems are proposed.

Keywords: PC mouse, finger joint modelling, arthroplasty

1. Legitimisation

In present day education, a classroom without a computer is almost unthinkable (Crawford, 2010). Practising e.g. mouse control, while flexing and extending the fingers many hours a day, includes some risk of overusing our finger joints. Recently, this specific relation has drawn the attention of only a few researchers, focusing respectively on finger joint pain in teachers (Ding et al., 2011), finger behaviour and PC mice (Lee et al., 2008), finger joint coordination (van Zwieten et al., 2010), and micro-trauma (Hedrih et al., 2005). Given the fact that 1 % of our population is subjected to rheumatoid arthritis (Gabriel et al., 1999) and that 5-20 % of young adults develop osteoarthritis (Mansat et al., 2007) - both chronic illnesses primarily affecting small finger joints - surprisingly few studies appeared in this clearly education-related domain, in contrast to e.g. the world of performing arts (Boyette, 2005).

2. Methodology

In a limited number of normal anatomical in-vitro specimens of the 2nd and 3rd finger, the small interphalangeal (IP) joints of a right hand were screened by extreme HR CT scanning. Transverse slices were matched, where possible, with an existing series of HR MRI 2 mm

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slices of an IP joint in the three orthogonal planes. A series of histological sections of the so-called Proper Collateral Ligament (PCL) of the Proximal Inter Phalangeal (PIP) joint of a 3rd finger was screened on ligamentous tissue (collagen, elastin) and checked on the presence of individual bundles within this ligament. In a normal anatomical specimen of a 3rd finger, bundles and their bony attachments were visualised by microdissection, with enlargements up to 40 X. By virtual modelling, bundles and bony phalanges to which they attach were represented as a crossed bar link mechanism, whose kinematic behaviour was analysed.

3. Results and findings

Trabecular structures inside the bone of the first phalanx's head (where the PIP joint begins) are mostly in line with cartilaginous fibres leaving the bone that continue as collagen fibres outside the bone, thus forming the PCL-bundles of the PIP joint. The same applies to their bony anchorages at the level of the base of the second phalanx (where the PIP joint ends) around its lateral tubercle. The first phalanx's head possesses two divergent condyli whose outer sides are characterised by the presence of a shallow groove or pit. This pit's circular margin has a somewhat doughnut-like appearance. The most superficial bundle of the PCL arises from this circular margin's proximal part, running obliquely distally, to insert above the second phalanx's lateral tubercle. A next, somewhat deeper bundle arises from the pit itself and runs obliquely distally, to end on top of the lateral tubercle. The deepest more distal bundle arises from the pit as well, running obliquely distally to insert above the second phalanx's lateral tubercle at its onset, thereby deep to the first bundle. In alternately flexing and extending the PIP joint, these bundles shift over each other like theatre wings. Histological staining did not reveal notable differences in elasticity between these PCL bundles. Once flexion starts, all crossing bundles become taut. Therefore they may be considered, together with the first phalanx's head and the second phalanx's base to which they attach, as a crossed bar linkage system. Flexing such a (virtual) PIP joint yields a spiral-like trajectory of the second phalanx's base. This spiral fits well with the curve of a first phalanx's condyle.

4. Scientific implications

Most of our anatomical and histological observations concerning the PCL are in accordance with literature (Kuczynski, 1968; Hintringer and Leixnering, 1991; Lewis et al., 1998). The PCL's most superficial fibre bundle however is not mentioned by these authors. Modelling these crossing bundles as a crossed bar linkage system that describes
the curvatures of the articular surfaces of the PIP joint's condyli, was performed before (van Zwieten et al., 2010), by applying so-called Chebyshev - linkages (http://web.mat.bham.ac.uk/C.J.Sangwin/howroundcom/straightline/Chebyshev1.html).

5. Practical implications

Arthroplasty with interphalangeal joint prostheses is currently recommended to overcome intractable rheumatoid arthritis and osteoarthritis (Luther et al., 2010). Small finger joint prostheses may however be improved with the help of our data on these finely tuned correlations between ligaments behaviour, and the shapes of joint surfaces.

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6. Social implications

Hand and finger problems, by intensively using e.g. PC mice during educational processes often have ergonomic causes (Lee et al., 2008; van Zwieten et al., 2010), which are solved by practical adaptations. Those considerable percentages however, that are eventually affected by osteoarthritis or rheumatoid arthritis, may be helped by finger joint prostheses that take into account our basic outcome data. Meanwhile whole hand robotics was proposed based on Chebyshev - linkages (Thayer et al., 2011). Only one prosthesis design however comes closest to our description (Ngalé Haulin et al., 2001).

7. Originality

A recent analysis represented condyli of the PIP joint as quasi circular (Loubert et al., 2007). As rightly demonstrated by later researchers however, these condyli have rather spiral curvatures (Dumont et al., 2008). Our present observations and analyses offer new, morphologically justified, original approaches to corroborate these latter findings.

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