MODELING OF THE STRESS-DEFORMED STATE OF THE FINGER JOINT

Taras CHECHEL

PhD student, Department of Biomedical Engineering, PhD student, Faculty of Electronic and Biomedical Engineering, Kharkiv National University of Radio Electronics, Kharkiv, Ukraine

Corresponding author: Taras Chechel, email: taras.chechel@nure.ua

Coordinator: Tatyana Nosova, PhD, Department of Biomedical Engineering, PhD, Associate Professor of the Department of Biomedical Engineering, Faculty of Electronic and Biomedical Engineering, Kharkiv National University of Radio Electronics, Kharkiv, Ukraine

Abstract. *Over the recent time period, computer modeling in medical practice complements the clinical picture of the study of injuries and pathological diseases, in a scientific and practical sense. At the same time, it is an integral part and component of medical treatment in world practice.*

Key words: *endoprosthesis, finger, joint, modeling, stress-strain state.*

Introduction

With the help of mathematical modeling the stress-strain state of elements of biological and biomechanical systems, it is possible to understand the fundamental nature of interaction of elements in biological and biomechanical systems with various injuries and further predict the results of surgical treatment [1]. Therefore, with the help of computer modeling, it will be possible to justify selective surgical treatment of injuries or pathological diseases, as well as to determine a set of parameters and characteristics of a metal fixator for surgical treatment of fractures [2-4].

Using computer modeling, it is possible to create a structured database on a description of various injuries and pathological diseases, as well as the use of various methods of surgical treatment, with appropriate use of various medical devices, for example, metal fasteners, orthoses, prostheses, and endoprostheses.

To study the contracture development process in finger joints, various types of experimental studies are performed. Mathematical modeling is the most economically feasible and the one that reveals the essence of fundamental research [5].

During finger flexion and extension, the movement of distal and proximal phalanx occurs in the same plane. Anatomically, the joints of fingers are arranged in such a way that the axis of rotation of a phalanx can be conventionally drawn in the joint. Therefore, from the point of view of mechanics, the finger can be represented as a planar hinge-lever system (Fig. 1), to which the law of conservation of energy can be applied.

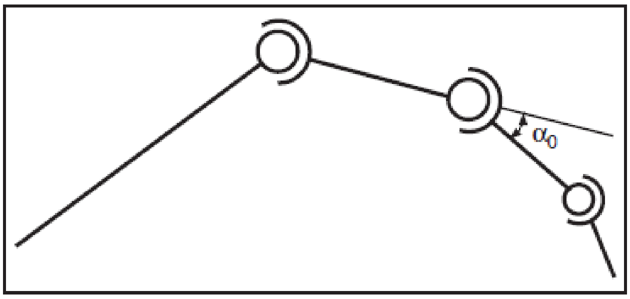

Fig. 1. Hinged scheme of a finger

Physiological position of a hand is energetically advantageous. Angle α_0 is the angle of rest of a proximal joint of the finger [6].

The carpo-phalangeal joint is spherical in shape, formed by the distal part of the metacarpal bone and a base of the proximal phalanx. The three axes of rotation are mutually perpendicular, allowing flexion and extension, adduction and abduction, and circular motion. The range of flexion movements in a healthy carpal-phalangeal joint is in the range from 0° to 90°, extension from 0° to 13°, abduction up to 50°, adduction up to 10°. There are collateral ligaments that strengthen the joint on its lateral surfaces. Additional palmar ligaments are located on the palmar surface of the capsule, which are closely connected with the fibers of a deep transverse carpal ligament. Performing ultra-precise and controlled movements of a hand is associated with complex biomechanical work in a metacarpal-phalangeal joint. The achievement of high functional indicators in rehabilitation process after endoprosthesis is directly related to accurate reproduction of individual anatomy of short tubular bones that form the articulating surface.

Conclusions

With the help of a model of joint movement, built on a basis of laws of conservation of energy, it is possible to determine a force required to overcome a certain degree of rigidity. Having measured the value of internal force, it is possible to calculate the corresponding external force, which must be provided by an external mechanical device to move the phalanges of different rigidities at any bending angle in the joint.

References

1. AVRUNIN O, TYMKOVYCH M, DRAUIL J. *Automatized technique for three-dimensional reconstruction of cranial implant based on symmetry, Proceedings of the Information Technologies in Innovation Business Conferenc*e (ITIB). 2015. p. 39-42.
2. ШИМОН В.М. *Математичне моделювання напруженодеформованого стану проксимального відділу стегнової кістки* / В.М. ШИМОН, В.В. СТОЙКА, М.А. ТКАЧУК, В.І. КУБАШ, О.В. ВЕРЕТЕЛЬНИК *// Вісник української медичної стоматологічної академії «Актуальні проблеми сучасноїмедицини»*. – 2016. – Т. 16, Вип. 4 (56), Ч. 2. – С. 48-53.
3. *Біомеханічні основи протезування та ортезування: навчальний посібник* / А.Д. САЛЄЄВА, В.В. СЕМЕНЕЦЬ, Т.В. НОСОВА, І.М. ВАСИЛЕНКО, П.О. БАЄВ, С.В. КОРНЄЄВ, О.М. ЛИТВИНЕНКО, І.В. КАРПЕНКО, І.М. ЧЕРНИШОВА – Харків: ХНУРЕ, 2022. – 352 с.
4. САЛЄЄВА А.Д., СОЛНЦЕВА І.Л., БЄЛЄВЦОВА Л.О., НОСОВА Т.В., СЕМЕНЕЦЬ В.В. *Виробничі технології та матеріали: Навч. посібник* / А.Д. САЛЄЄВА, ХАРКІВ: – І.Л. СОЛНЦЕВА, Л.О. БЄЛЄВЦОВА, Т.В. НОСОВА, В.В. СЕМЕНЕЦЬ. 92 с.–ХНУРЕ, 2022.
5. ЛАЗАРЕВ І.А. *Розподіл зусиль у різних ділянках згинального апарату пальців кисті при стандартному навантаженні* / І.А. ЛАЗАРЕВ, І.М. КУРІННИЙ, М.Л. Ярова та ін. Травма. 2013. Т. 14, № 6. С. 73-82.
6. НАУМЕНКО Л.Ю. *Математичне моделювання роботи проксимального міжфалангового суглоба пальця кисті при різних видах тугорухомості* / Л.Ю. НАУМЕНКО, К.Ю. КОСТРИЦЯ, М.А. АРБУЗОВ, А.О. МАМЕТЬЄВ // Одеський медичний журнал. – 2018. – № 5. – С. 9-14.