NEW WAYS TO SOLUTION PROSTHETICS FOR EXTENSIVE DEFECTS OF THE JOINTS AND BONES OF THE HAND. LITERATURE REVIEW

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Abstract

The human hand is an organ of labor, self-service, touch. According to Kaplan E.V. the hand is an extension of our brain in the environment around us. However, being one of the most functionally loaded systems, the hand and its bone segments are damaged quite often.

***The purpose** of this work is to analyze a literary review of modern prostheses in the treatment of diseases of the bones and joints of the hand.*

***Material and methods.** We systematically searched the literature and selected sources from MEDLINE, Cochrane databases, Google Scholar, PubMed, as well as research papers and online educational publications in English and Russian. Forty papers that met the inclusion criteria were included.*

***Results.** The review article presents methods of treating patients with defects and injuries of the bones and joints of the hand, the causes of the development of this pathological condition.*

***Conclusion.** Thus, the existing types of prostheses currently do not fully meet the needs of patients and do not have a 100% positive effect from their use in modern reconstructive surgery. The number of unsatisfactory results of reconstructive operations and disability rates remain high.*

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Conflict of interest
The authors declare that they have no conflicts of interest

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Қол буындары мен сүйектерінің ауқымды ақауларын протездеудің жаңа шешімдері. Әдебиет шолуы

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Аңдатпа

Адам қолы – еңбек, өзіне қызмет ету ағзасы. Е.В. Капланның айтуынша қол - бізді қоршаған ортадағы миымыздың жалғасы. Дегенмен, ең функционалды жүктелген жүйелердің бірі бола отырып, қол және оның сүйек сегменттері жиі зақымдалады.

***Жұмыстың мақсаты:** қол сүйектері мен буындарының ауруларын емдеудегі заманауи протездеу әдістеріне әдеби шолу жасау.*

***Материал және әдістер.** Біз әдеби деректерді MEDLINE, Кокран дерекқоры, Google Scholar, PubMed базаларында, сонымен қатар ағылшын және орыс тілдеріндегі ғылыми-зерттеу жұмыстары мен онлайн басылымдары бойынша жүйелі түрде шолу жасадық.*

***Нәтижелер.** Шолу мақаласында қолдың сүйектері мен буындарының ақаулары мен жарақаттары бар науқастарды жаңа емдеу әдістері мен осы патологиялық жағдайдың даму себептері көрсетілген.*

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Түйін сөздер:
эндопротездеу, биопротез, биобаспа, қол буындары, қол жарақаттары, реконструктивтік хирургия.

Қорытынды. *Осылайша, протездердің қолданыстағы түрлері қазіргі таңда науқастардың қажеттіліктерін толық қанағаттандырмайды және оларды заманауи реконструктивтік хирургияда қолдану 100% оң нәтиже бере алмайды. Қалпына келтіру операцияларының қанағаттанарлықсыз нәтижелерінің саны және мүгедектік көрсеткіштері осы күнге дейін жоғары болып қалып отыр.*

Новые пути решения протезирования при обширных дефектах суставов и костей кисти. Обзор литературы

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Конфликт интересов
Авторы заявляют об отсутствии конфликта интересов

Аннотация

Кисть человека – это орган труда, самообслуживания, осязания. По выражению Каплана Е.В. рука является продолжением нашего мозга в окружающей нас среде. Однако, будучи одной из наиболее функционально нагруженных систем, кисть, составляющие ее костные сегменты, повреждается достаточно часто.

Цель работы – *провести литературный обзор современных протезов в лечении заболеваний костей и суставов кисти.*

Материал и методы. *Мы провели систематический поиск литературных данных и отобрали источники из MEDLINE, базах данных Кокрейна, GoogleScholar, PubMed, а также исследовательские работы и учебные онлайн-издания на английском и русском языках. Были включены сорок работ, которые удовлетворяли критериям включения.*

Результаты. *В обзорной статье приведены методы лечения пациентов с дефектами и повреждениями костей и суставов кисти, причины развития данного патологического состояния.*

Выводы. *Таким образом, существующие виды протезов на данный момент не полностью удовлетворяют потребности пациентов и не оказывают 100% положительный эффект от их применения в современной реконструктивной хирургии. Количество неудовлетворительных результатов реконструктивных операций и показатели инвалидности сохраняются высокими.*

Ключевые слова:
эндопротезирование, биопротез, биопечать, суставы кисти, повреждения кисти, реконструктивная хирургия

Relevance

The human hand is an organ of a complex anatomical structure, a fine physiological function, and perfect coordinated movements. “In the absence of other evidence, the thumb alone would convince me of the existence of God” (Isaac Newton, cited in James Le Fanu, 2003). This is the organ of labor, self-service, touch. According to Kaplan E.V. the hand is an extension of our brain in the environment around us. However, being one of the most functionally loaded systems, the hand and its bone segments are damaged quite often [1,2].

The purpose of this work is to analyze a literary review of modern prostheses in the treatment of diseases of the bones and joints of the hand.

Material and methods

We conducted a systematic search of literature data and selected sources from MEDLINE, Cochrane databases, Google Scholar, PubMed, as well as research papers and online educational publications in English and Russian. Forty works that met the inclusion criteria were included.

Inclusion criteria

We included 40 sources that met our inclusion criteria: works in which studies were conducted in patients with defects of bones and joints of the hand, sources published no later than 10 years.

Reliability assessment and data extraction

We tried to evaluate a sample of 30 sources in which attention was paid to the treatment and prevention of this pathological condition. We evaluated the articles in random order based on key aspects. The data elements taken for this article included: study design, sampling method, number of patients and operations performed, outcome determination, randomized controlled trials.

Results

According to many authors, the share of injuries

of the hand and fingers among injuries of the musculoskeletal system ranges from 19.1 to 46.6%, and disability - from 13-30%. The main reasons leading to dysfunction of the fingers are: intra-articular fractures of the phalanges and metacarpal bones with a defect in the articular surfaces; non-fused intra-articular fractures, ankylosis, and contractures of joints in a functionally disadvantageous position [3,4,5].

In the general structure of fractures of the bones of the hand, the bones of the wrist account for 9%, fractures of the metacarpal bones account for up to 35%, and phalanges of the fingers – 15-20%. In 23%, there are multiple fractures of the bones of the hand in combination with injuries to tendons, nerves, ligaments, and other anatomical structures [6,7]. Victims after severe injuries to the hand are limited in their choice of profession and often become disabled. Disability in case of damage to this zone is consistently held in the first position among all skeletal pathologies and reaches 13–30% among all examined patients. [8,9,10,11].

In case of a serious dysfunction of the joint (before the development of significant deformities, joint instability, contractures, and muscle atrophy), with a pronounced pain syndrome that is not amenable to conservative treatment, joint arthroplasty is indicated in table 1 [12,13].

Diseases that cause persistent dysfunction of the joints of the hand and have indications for arthroplasty	- idiopathic and post-traumatic arthrosis; - post-traumatic defects of the joints of the fingers; - degenerative and post-infectious arthrosis; - bone ankylosis; - incorrect position (for example, with arthrosis, due to injury, improper loads, etc.); - congenital bone pathology of the joints; - the initial stages of rheumatoid arthritis and psoriasis. - oncological bone formations requiring the removal of large areas of the bone.

Table 1.
Indications for surgery

During the medical rehabilitation of patients with the consequences of injuries to the bones and joints of the fingers, various methods of conservative and surgical treatment are used: open repositioning, metal osteosynthesis with Kirschner wires or screws, hinge-distraction devices for external fixation, arthroplasty or remodeling resection of the articular surfaces, corrective osteotomy, tenolysis and capsulotomy, endoprosthesis replacement, arthrodesis, resection of articular surfaces [14,15].

As practice shows, arthroplasty of joints in the hand with their persistent deformity, as well as adult patients with deforming arthrosis of a traumatic and degenerative-dystrophic nature, is the method of choice in restoring lost function [16,17].

The most common are hingeless and hinged designs of endoprostheses. Recently, prostheses Swanson, Synthes (Mathys), WEKO, the hinged prosthesis Link, New Flex and a number of others have been implanted. However, the piston-like movement of the stem of a hingeless endoprosthesis in the bone marrow canal in the long term leads to erosion, lysis of the bone mass and, in 46–57%, to destabilization of the prosthesis. According to T.J. Joyce, R.H. Millner, A. Unsworth , during revisions of one-piece endoprostheses designed by Swanson and Sutter in terms of 32 to 53 months, fractures of the prosthesis stem were observed in 27–45% of cases, which were removed. Articulated types of prostheses do not correspond to the geometric and biomechanical features of the metacarpophalangeal joints. When the prosthesis moves at the level of the joint, the tissues are constantly injured, which leads to inflammation of the tissues and necrosis of the skin [18,19].

In addition, there is a NEUFLEX silicone implant offered by the Institute of Rheumatology named after I.M. Sechenov, Moscow. This implant is used to treat ulnar deviation in rheumatoid arthritis.The results of arthroplasty with such an implant were obtained: elimination of the extension deficit. Of the complications noted: dislocation of the implant, fracture of the implant. At the same time, it is not possible to detect fractures of silicone implants on X-ray images. Silicone synovitis was also noted as a reaction to microcorticosteroids intraarticularly, bayonet deformity of the II metacarpophalangeal joint [20,21,22,23,24].

The Ilizarov apparatus, created in 1951, is still offered as a method of treating post-traumatic deformities of the bones of the hand, while maintaining a fairly high percentage of complications of its use [25,26,27,28,29].

A functional method of treatment (skeletal traction for the nail phalanx) often causes complications in the form of necrosis and suppuration of the nail phalanx, and bedsores on the palmar surface of the finger from tire pressure.

There is a report on the use of carbon composite material in the creation of a prosthesis that does not exactly repeat anatomical structures. The material successfully took root and patients returned to working capacity immediately after the operation. But 18 years after a household injury, the endoprosthesis was dislocated, the prosthesis was forced to be removed, and the patient was taken to the disability group [30].

Foreign authors, including domestic ones, prefer ceramic prostheses.Ceramic prostheses have shown themselves in practice as the most biocompatible materials, they do not corrode and do not have a toxic effect on the body. However, according to the Institute of Orthopedics and Traumatology. R.R. Harmful, ceramic prostheses in friction pairs release microparticles of aluminum oxide and gradually come to destruction within 10-15 years. The stages of the operation on the hand are shown in figure 1 [31,32,33,34,35].

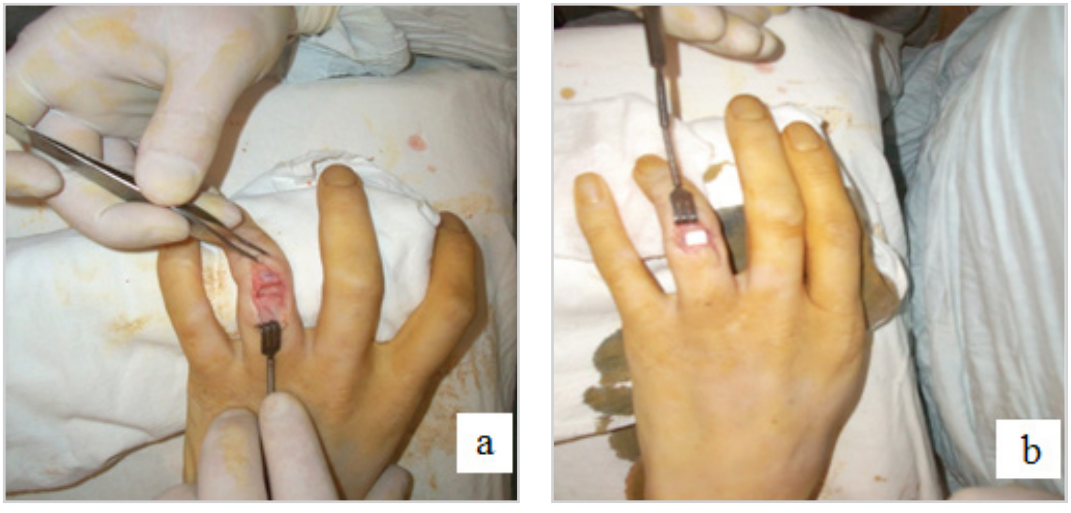

Figure 1.
a - resection of articular surfaces,
b - prosthesis implantation

All the types of hand joint prostheses presented above do not have the property of an exact repetition of anatomical structures, that is, they are unnatural and, by their nature, are foreign to the human body, causing various kinds of complications.

With the creation of 3D printing technologies and their application in industry, the idea arose to introduce them into medicine. There are first successful tests of 3D technology in the creation of prostheses for bones and joints. Among them: The Next21 Japanese team of scientists from the Institute of Physical and Chemical Research and the University of Tokyo, which used 3D printing technology to create exact copies of human bones. The material from which NEXT21 creates prostheses is calcium phosphate, which is found in natural bones. The technology has so far only been applied to animals and is awaiting approval from the Pharmaceutical Control Committee. In addition, the prosthesis, according to scientists, will fuse with natural bone on its own within a few weeks. Information that the prosthesis will be replaced by bone tissue has not yet been provided.

Scientists from the US also report successful proof of the hypothesis of creating a 3D copy of a human bone, consisting of hydroxyapatite and bioactive glass. The result has not yet been applied in clinical trials [36,37,38].

Computed tomography images are used to create copies of human bones, after their processing a 3D image is obtained that can be used to print exact copies of bones [39,40]. According to the same sources, the possibility of bioprinting articular ligaments is reported.

Conclusion

Thus, our analysis of the literature indicates the high importance of the problem of dysfunction of the hand, as a result of injuries and diseases of the joints of the fingers, leading to severe disability. The existing types of prostheses at the moment do not fully satisfy the needs of patients and do not have a 100% positive effect from their use in modern reconstructive surgery. The number of unsatisfactory results of reconstructive operations and disability rates remain high. The consequences of damage to the joints of the fingers of the hand are distinguished by a variety of forms of lesions and require individualization of approaches to the construction of treatment tactics. The issue of using 3D technologies in the creation of hand bone prostheses that can be replaced by bone tissue remains controversial and relevant.

All of the above determines the medical and social significance of the problem of restorative treatment of patients and disabled people with the consequences of injuries of the joints of the fingers, which requires further scientific development.

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