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Original article

Arthrodesis of the I Metatarsophalangeal Joint in the Treatment of Hallux Rigidus

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Abstract

The high prevalence and functional significance of the joint determines the relevance of the treatment of osteoarthritis of the I metatarsophalangeal joint (MTPJ). Given the disabling nature of hallux rigidus, which significantly impairs mobility and quality of life, ongoing research into its causes and treatment options remains critical.

The study aims to assess the operation's result at the III-IV degrees of arthrosis and determine its effectiveness in improving the forefoot's functionality after arthrodesis on the I MTPJ.

Methods. Ninety-nine patients with arthrosis I MTPJ were examined, which included 69 female and 30 male patients. All patients have III-IV a degree of the deformation of the I-phalangeal joint and intense pain syndrome. The number of patients with the idiopathic form was 77 patients, 17 patients with concomitant rheumatoid arthritis and 1 patient with gout, 4 patients had post-traumatic deformities. An outcome study was performed using clinical and radiological data. However, two VAS and AOFAS rating scales were used.

Results. A survey was conducted to measure pain and assess the condition of patients before and after surgery using the VAS and AOFAS scales. The results showed that the pain rate among all 99 patients dropped from 8.7 to 0.5. Also, the AOFAS score improved from an average of 34 to 87. Most patients (77) rated the results as "excellent", while 22 patients rated them as "good". Ratings "fair" or "poor" were not received.

Conclusion. Arthrodesis is an effective surgery for arthritis of the I MTPJ, but it's important to weigh the benefits against the potential complications.

Keywords: Hallux rigidus, arthrodesis of the first metatarsophalangeal joint.

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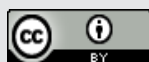
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Introduction

Hallux rigidus (HR) - is limited mobility in the I metatarsophalangeal joint (MTPJ) due to deforming arthrosis. The high prevalence and functional significance of the joint determines the relevance of the treatment of osteoarthritis of the I MTPJ [1-3]. Hallux rigidus is the second most common disease I MTPJ after hallux valgus. It occurs in about 1-2% of the world's population [4-6]. Since the publication of the first work about the hallux rigidus, a have been conducted a sufficient number of studies have been widely and in detail studied arthrosis of the I MTPJ [7-11]. Despite this, the etiology of the disease in most cases is idiopathic, but many variants are also assumed, starting with excessive metatarsal length and ending with a genetic predisposition.

Given the disabling nature of hallux rigidus, which significantly impairs mobility and quality of life, ongoing research into its causes and treatment options remains critical. While arthrodesis is often considered the "gold standard" for advanced stages, joint replacement (endoprosthesis) of the I MTPJ presents a viable alternative for preserving joint function.

However, the long-term success of joint replacement varies based on factors such as prosthetic design and surgical technique. As the prevalence of osteoarthritic conditions rises globally, further studies comparing the outcomes of arthrodesis and joint replacement are essential to optimize surgical protocols and improve patient outcomes.

If conservative treatment is ineffective, a surgical method of removing the pathology is resorted to.

Materials and methods

All 99 patients were operated on at the National Scientific Center Traumatology and Orthopedic named after Academician N.D. Batpenov, from 2018 to 2023 was operated on with the diagnosis «Arthrosis I MTPJ», of which 30 were male and 69 female. The age ranged from 18 to 76 (average age 55.24 ± 11.52). Stages of arthrosis I MTPJ range from III to IV. All patients were operated because of severe pain. The preoperative diagnoses included 77 idiopathic arthroses and four post-traumatic arthroses. In addition, there were 17 patients with concomitant rheumatoid arthritis and 1 patient had concomitant gout. The inclusion criteria for the study were the presence of persistent pain syndrome clinical and (or) radiological manifestations of arthrosis of the I MTPJ. The criteria for exclusion were: under 18 years of age, iatrogenic arthrosis, repeated operations after unsuccessful primary interventions, and arthropathy in various systemic inflammatory diseases. The

Collier M. was the first who describe the arthrodesis of the I MTPJ in 1894 using an ivory pin for internal fixation and reported satisfactory results [5]. Since then, various surgical methods for correcting HR have been published: cheilectomy, Keller resection arthroplasty, arthrodesis, metatarsal osteotomy and joint replacement [9-13].

The method of surgical treatment is determined by the degree of joint osteoarthritis, with arthrodesis of the metatarsophalangeal joint considered the "gold standard" for treating stage III-IV osteoarthritis. In this study, the Coughlin and Shurnas classification was used to guide surgical decision-making. According to this classification, cheilectomy is recommended for stages I-III osteoarthritis, while arthrodesis is indicated for stages III-IV. The primary disagreement concerns stage III: if more than 50% of degenerative cartilage damage is detected, arthrodesis is preferred; otherwise, cheilectomy is performed [12-15].

This article evaluates the outcomes of surgical treatment in which arthrodesis was the primary method and analyzes the relationship between different fixation techniques. In this study, joint fixation was performed with double Herbert compression screws and dorsal plates.

The study aims to assess the operation's result at the III-IV degrees of arthrosis and determine its effectiveness in improving the forefoot's functionality after arthrodesis on the I MTPJ.

degree of deformation was assessed by X-ray before and after the surgery by determining the main reference lines and angles followed by the construction of the skiagram.

Two scales were used to assess performance and outcomes: The Visual Analog Scale (VAS) and The American Orthopedic Foot and Ankle Society (AOFAS).

The VAS was used to assess the patient's health before and after surgery. Each patient was asked to subjectively rate the pain on a scale of 100, where 0 indicates no pain, and 100 represents the presence of severe pain.

The AOFAS has a maximum rating of 100 [16]. Of these, 40 points are awarded for pain assessment, 45 points for functionality, and 15 points for equalization. In this study, the AOFAS scale remained unchanged, even though the maximum score for arthrodesis I MTPJ was 90, as movement in the metatarsal joint was only 10.



Figure 1 - A) X-ray image before arthrodesis. B) Arthrodesis I MTPJ with Herbert screws

Operating techniques. The mean time for surgery was 40 minutes. The operation consists of a mini-access

intervention under the harness, in which a medial cut was made in the I MTPJ projection. The second step was the

isolation of the metatarsal head and the base of the proximal phalanx, followed by removal/resection of the articular surfaces and cheilectomy with bone modeling using a saw. Fixation of the joint is performed with a plate or two intercrossing Herbert compression screws.

When the plate is fixed, the joint bed is formed and further due to the reposition of bone fractures at an angle of 15 degrees, osteosynthesis is carried out. The same procedure is there when fixing with Herbert screws.

Early activation of patients was performed on the 1st day after surgery with the help of additional means of external support (walkers, crutches, baruki) without supporting the load on the forefoot. After the first day, the radiological images and range of motion were assessed by routine examination, and the postoperative sutures were evaluated (consistency, presence of infection). Preliminary

Results

This study included an analysis results 99 patients of the long-term results (from 1 to 6 years) of surgical treatment of arthrosis I MTPJ. There were made 99 operations, of which 94 (94.9%) operations were successful, and 5 (5.1%) patients with a complication (Table 1). Two scales were used to evaluate the results of surgical treatment.

Two scales VAS and AOFAS surveys were conducted with the 99 patients before and after surgery.

The results on the AOFAS scale were distributed as follows: the numbers of "excellent" results were 77% (77 patients), good results - 22% (22 patients), "satisfactory" and "unsatisfactory" results were not obtained. The mean pain level improved from 34 points preoperatively to 87 points. When evaluating the AOFAS indicator depending on the "Fixation method" indicator, it was possible to identify statistically significant differences (p<0.05). The median score on the AOFAS scale before surgery was

and long-term results were evaluated using clinical and radiological methods 2 months after discharge.

Statistical analysis. The data analysis was performed using the SPSS program, version 21.0 (IBM Corp., Armonk, NY). The Wilcoxon method was used to compare the results of the fixation method between groups. The proportions were compared using a CHI-squared test. Quantitative indicators were evaluated for compliance with the normal distribution using the Shapiro-Wilk criterion. Qualitative features were described in frequencies (percentages), arithmetic averages (M), and standard deviations (SD) were used for indicators with a normal distribution, and medians (Me) and lower and upper quartiles (Q1-Q3) were used for indicators with an abnormal distribution, and p<0.05 was considered statistically significant.

33 (interquartile range from 26 to 40), after surgery, it decreased to 1 (interquartile range from 1 to 1), which is statistically significant (p<0.05).

The mean VAS scale pain level improved from 8.7 to 0.5 points. Based on the obtained data, when evaluating the VAS indicator depending on the "Fixation method" indicator, we found statistically significant differences (p<0.05). In our study, the median of the pain syndrome before surgery was 7 points (interquartile range from 6 to 9 points), after surgery, the median of the pain syndrome decreased to 1 point (from 0 to 0 points) according to VAS, which is statistically significant (Table 2).

Statistically significant differences $\chi^2=0.08$, p<0.05 were found in the analysis of the conjugacy between complications and the material of use using the CHI-squared test.

Table 1 - Description of the indicators of the values

Variables	Descriptive characteristic
Age	55,24±11,52
Gender	
Male (0)	30 (30,3%)
Female (1)	69 (69,7%)
VAS 1	7 (6-9)
AOFAS 1	33 (26-40)
Etiology:	
Idiopathic (1)	77 (77,8%)
Rheum. arthritis, gout (2)	18 (8,2%)
Posttraumatic(3)	4 (4,0%)
Complications:	
No (0)	94 (94,9%)
Yes (1)	5 (5,1%)
The fixation method :	
Plates	42 (42,4%)
Herberts screw	57 (57,6%)

*Qualitative features were described in frequencies (percentages), arithmetic averages (M), and standard deviations (SD) were used for indicators with a normal distribution, and medians (Me) and lower and upper quartiles (Q1-Q3) were used for indicators with an abnormal distribution

In our study were used two fixation methods: a plate (42.4%) and two Herbert compression screws (57.6%). During the period from 2018 to 2023, there were 5 patients with complications with a "failed arthrodesis" diagnosis, who repeatedly complained of increased pain. In all 5 cases were used the plate. Three of the five complications were associated with idiopathic arthrosis of the I MTPJ, while the other two cases had a related diagnosis. The first case is associated with post-traumatic arthrosis, and the second

case is associated with rheumatoid arthritis. The next tactic was to remove the plate and choose a suitable method to eliminate complications. In the first case, arthrodesis of the I MTPJ was performed using bone autoplasty, and in other cases were made decortication and tunneling, as well as removal of fibrous tissue and fixation with two Herbert compression screws.

Table 2 - Comparative analysis of the results of VAS and AOFAS

No	Scale	Before, n=	After, n =	P Mean
1	AOFAS	33(26-40)	1(1-1)	<0,05
2	VAS	7(6-9)	0	<0,05

Discussion

The results of this study confirm the high effectiveness of arthrodesis in the treatment of I MTPJ osteoarthritis. According to the AOFAS scale used in this study, the mean score increased from 34 to 87, and the median decreased from 33 to 1 after surgery, indicating significant improvement in patients' functional status. Similar results were demonstrated in the study by Ho et al. where significant improvement in functional outcomes after I MTPJ arthrodesis was also observed [17]. According to the VAS scale, the mean pain level decreased from 8.7 to 0.5 points, and the median pain score decreased from 7 to 1 point, indicating successful relief of pain syndrome following the surgical intervention.

Conclusions

In conclusion, arthrodesis has proven to be an effective surgical method for the treatment of osteoarthritis of the I MTPJ, as demonstrated by the high success rate 94 out of 99 surgeries (94.9%) in the conducted study. This procedure effectively eliminates pain and restores foot functionality, significantly improving the quality of life for patients. However, it is crucial to carefully consider individual patient characteristics and potential post-surgical complications before proceeding with arthrodesis.

The study also highlighted a notable difference in outcomes based on the fixation method used. Two fixation methods were used in the study: plates (42.4%) and two Herbert compression screws (57.6%). All complications were associated with the use of plates, which suggests a potential correlation between the choice of fixation method and the likelihood of complications. This finding underscores the importance of selecting the appropriate fixation technique to minimize risks.

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The statistically significant differences in outcomes depending on the fixation method highlight the critical role of selecting the optimal technique to achieve the best clinical results. The complication analysis also revealed significant differences depending on the materials used, underscoring the need for careful selection of materials to minimize the frequency of complications. These findings are consistent with the results of the study by Smith et al., who also emphasize the importance of proper fixation method and material choice for successful outcomes in MTPJ osteoarthritis treatment [18].

Despite the generally positive outcomes, arthrodesis remains a topic of debate among surgeons due to the invasive nature of the procedure. Many surgeons continue to explore organ-preserving techniques as alternatives to arthrodesis, aiming to achieve effective treatment outcomes while minimizing surgical intervention. Further research and discussion are necessary to refine surgical approaches and optimize patient care in the treatment of I MTPJ osteoarthritis.

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Hallux rigidus емдеудегі І табан сүйегі-бақайшық буынының артродезі

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Түйіндеме

Таралуы жиілігі мен функционалдық маңыздылығы І табан сүйегі-бақайшық буыны (ТСББ) остеоартритін емдеудің өзектілігін анықтайды. Науқастың қозғалысын шектеу арқылы өмір сапасын айтарлықтай нашарлататын hallux rigidus-тың мүгедектік сипатын ескере отырып, оның себептері мен емдеу әдістерін үздіксіз зерттеу маңызды болып қала береді.

Зерттеудің мақсаты: Артроздың III-IV дәрежесіндегі емдеу нәтижесін бағалау және І ТСББ артродезінен кейін табанның алдыңғы бөлігінің функционалды тұрғысынан жақсару тиімділігін анықтау.

Әдістері. Бұл ғылыми мақалада І ТСББ артрозы бар 99 науқас зерттелді, оның ішінде 69 әйел және 30 ер адам болды. Барлық науқастарда III-IV дәрежедегі метатарсофалангиальды буын артрозы және қарқынды ауырсыну синдромы болды. Идиопатиялық нысаны бар науқастардың саны - 77 адам, сондай-ақ екіншілікті ревматоидты артриті бар 17 науқас және подаграсы бар 1 науқасты құрады, ал 4 науқас жарақаттан кейінгі жағдайда болды. Нәтижелерді зерттеу клиникалық және рентгенографиялық деректерді қолдану арқылы жүргізілді. Сонымен қатар, ВАШ және AOFAS рейтингтік екі шкаласы қолданылды.

Нәтижесі. ВАШ және AOFAS шкалаларын қолдана отырып, отаға дейінгі және одан кейінгі ауырсыну деңгейін өлшеу және науқастардың жағдайын бағалау үшін сауалнама жүргізілді. Нәтижелер барлық 99 науқастағы ауырсыну деңгейі орташа есеппен 8,7-ден 0,5 баллаға дейін төмендегенін көрсетті. Сондай-ақ, AOFAS шкаласы бойынша балл 34-тен 87-ге дейін жақсарды. Қатысушылардың көпшілігі (77 адам) нәтижелерді "керемет" деп бағалады, ал 22 науқас нәтижені "жақсы" деп бағалады. "Қанағаттанарлық" және "қанағаттанарлықсыз" бағалаулар анықталған жоқ.

Қорытынды. Артродез - бірінші ТСББ емдеудің тиімді әдісі, бірақ оның артықшылықтарымен бірге асқыну ықтималдығын қарастырған жөн.

Түйін сөздер: Hallux rigidus, І табан сүйегі-бақайшық буынының артродезі.

Артродез І плюснефалангового сустава в лечении Hallux rigidus

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Резюме

Высокая распространенность и функциональная значимость сустава обуславливают актуальность лечения остеоартроза I плюснефалангового сустава (ПФС). Учитывая инвалидизирующий характер hallux rigidus, существенно ухудшающий подвижность и качество жизни, продолжающиеся исследования его причин и вариантов лечения остаются критически важными.

Цель исследования: оценка результата лечения при III-IV степенях артроза и определение его эффективности в плане улучшения функциональности переднего отдела стопы после артродеза на I ПФС.

Методы. В данной научной статье были исследованы 99 пациентов с артрозом I ПФС, из них 69 пациентов женского пола и 30 пациентов мужского пола. У всех пациентов III-IV степень артроза I плюснефалангового сустава и интенсивный болевой синдром.

Количество пациентов с идиопатической формой составило - 77 пациентов, так же 17 пациентов с сопутствующим ревматоидным артритом и 1 пациент с подагрой, 4 пациента имели посттравматический характер деформаций. Изучение результатов было выполнено с использованием клинических и рентгенологических данных. Вместе с тем, были использованы рейтинговые две шкалы ВАШ и AOFAS.

Результаты. Проведен опрос для измерения уровня боли и оценки состояния пациентов до и после операции, используя шкалу ВАШ и AOFAS. Результаты показали, что уровень боли снизился среди всех 99 пациентов в среднем с 8.7 до 0.5 балла. Также, оценка по шкале AOFAS улучшилась с 34 до 87 баллов. Большинство пациентов (77 человек) оценили результаты как «отличные», в то время как 22 пациентов оценили их как «хорошие». Никакие оценки «удовлетворительно» и «неудовлетворительно», не были получены.

Выводы. Артродез является эффективным методом лечения артроза первого плюснефалангового сустава, однако важно взвесить его преимущества против потенциальных осложнений.

Ключевые слова: Hallux rigidus, артродез I плюснефалангового сустава.