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ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

**GEORGIAN MEDICAL NEWS**

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**GMN: Georgian Medical News** is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.

GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

**GMN: Медицинские новости Грузии -** ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

**GMN: Georgian Medical News –** საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.

ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

**WEBSITE**

www.geomednews.com

## К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

**При нарушении указанных правил статьи не рассматриваются**.

## REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

**Articles that Fail to Meet the Aforementioned Requirements are not Assigned to be Reviewed.**

## ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**, ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ, რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

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*Содержание:*

# ANKLE DISTRACTION ARTHROPLASTY: A SYSTEMATIC REVIEW

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## Abstract.

**Background:** Epidemiological data suggest 9%-15% of ankle joint osteoarthritis (AOA) in the general population. One of the methods of delaying radical intervention is ankle joint distraction arthroplasty of the ankle joint (ADA), including a combination of various techniques. The lack of publications summarizing the maximum possible clinical data on ADA for more than 50 years of the method's history justifies the need for a review.

**Methods:** A systematic review of ankle distraction arthroplasty followed the 2020 PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) protocol guidelines. The inclusion criteria were articles with clinical data in full text in English, available on the Internet for the maximum possible period, including the treatment of diseases of the ankle joint using distraction arthroplasty.

**Results:** At the search stage, 4640 publications from 3 sources were identified. 33 articles were selected for analysis of the full texts of the articles. Additionally, 1 article was excluded, as it contains duplicate information from an identical study. The analysis of the full texts of 32 publications was made, according to the parameters indicated earlier. A total of 927 patients underwent ADA. The mean age of the patients was 44.9 ± 12.7 years. Among the causes, post-traumatic AOA was indicated in 26 (81.3%) publications, osteochondral defects (n=2, 6.3%), consequences of poliomyelitis (n=4, 12.5%), congenital deformities (n=4, 12.5%), hemophilia (n= 2, 6.25%), idiopathic juvenile osteoarthritis (n=1, 3.1%), rheumatoid OA (n=1, 3.1%).

**Conclusions:** Despite the more than 50-year history of ADA, there is still no sufficient understanding of this methodology. The goal of future research is to understand the exact indications for ADA depending on the stage, etiology, and type of AOA. ADA is a promising effective method of treatment that allows achieving an improvement in function and a reduction in pain in the medium and long term while preserving the patient's joint.

**Key words.** Ankle joint, osteoarthritis, external fixators, arthroplasty, systematic review.

## Introduction.

Epidemiological data suggest 9%-15% of ankle joint osteoarthritis (AOA) in the general population [1]. Among the causes of AOA are post-traumatic 70%-78% osteoarthritis (OA), 12%-13% rheumatoid OA, 7%-9% idiopathic [1-3]. Post-traumatic osteoarthritis has the following etiological structure: ankle fractures 37%, pilon fractures 9%, chronic instability 14.6%, talus fracture 8.3% [2].

For many years, arthrodesis was considered the gold standard for the treatment of terminal stages of AOA. The modern view of the problem allows a paradigm shift towards the equivalence of total arthroplasty and arthrodesis, including arthroscopic arthrodesis [4-6]. Ankle arthroplasty has a similar complication rate to arthrodesis, about 9%, leading to either revision arthroplasty or arthrodesis [7,8]. In the long term, arthrodesis has a negative impact on adjacent joints [9,10]. One of the methods of delaying radical intervention is ankle joint distraction arthroplasty of the ankle joint (ADA), including a combination of various techniques [11].

The main task in ADA is the creation of a significant separation of the articular surfaces and the maintenance of negative pressure in the joint cavity to create conditions for the restoration of cartilage tissue. Technically, arthrodiastasis is achieved using an external fixator (EF) [11].

There are various variations of models of external fixation devices, with or without the possibility of movement in the joint. Volkov-Oganiesian's device can be considered one of the first articulated ankle devices described, but it was used to treat chronic ankle fractures in combination with the creation of arthrodiastasis [12]. The first description of EF for the treatment of AOA belongs to Judet R. & Judet T. [13]. Unfortunately, there are no photos of their EF models. We tried to trace the evolution of the main EF models for ADA, except for combinations with supramalleolar osteotomy, according to the earliest sketches or photographs of the authors (Figure 1), but many other proposed models are not shown in our article. There are data on the use of industrial distractors or analogs of ExFix systems [14,15].

To date, there are many literature reviews devoted to ADA, each of which has made an invaluable contribution to the development of the method. Most of them are reviews that don't explicitly indicate adherence to the generally accepted evidence methodology, or simple reviews of the literature [20-33]. There is a systematic review comparing ADA with other cartilage preservation methods Rivera & Beachler 2018 [34]. A systematic review on the treatment of AOA against the background of hemophilia, including the use of ADA Barg et al. 2016 [35].

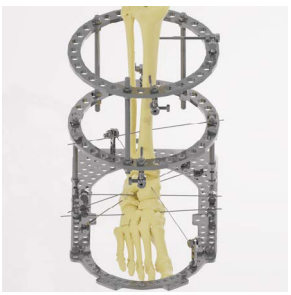
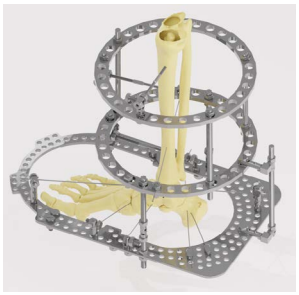
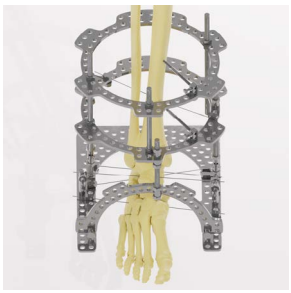
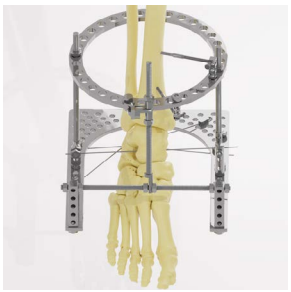
The lack of publications summarizing the maximum possible clinical data on ADA for more than 50 years of the method's history justifies the need for a review.

The purpose of a systematic review of the literature is to determine the indications, clinical efficacy, results, and analysis of the methodology for treating patients with AOA using ADA in any combination.

## Materials and methods.

A systematic review of ankle distraction arthroplasty followed the 2020 PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) protocol guidelines [36]. The inclusion criteria were articles with clinical data in full text in English, available on the Internet for the maximum possible period, including the treatment of diseases of the ankle joint using distraction arthroplasty.

***Figure.1.*** *Evolution of external fixator designs.*

| | | |
|---|---|---|
| Volkov-Oganiesian, 1975 [12] |  |  |
| Roermund & Valburg, 1995 [16] |  |  |
| Paley, 2008 [17] |  |  |
| Saltzman, 2012 [18] |  |  |
| Fragomen, 2014 [19] |  |  |

**Searching.**

Information was searched using PubMed, Scopus, Scholar Google databases from December 1 to December 15, 2021. The authors of the study were not contacted to obtain additional data. An advanced search query was performed to collect data from PubMed (https://pubmed.ncbi.nlm.nih.gov/advanced/) and Scopus (https://www.scopus.com/search/form.uri?display=advanced) databases. Harzing's Publish or Perish (macOS GUI edition) 8.1 (Publish or Perish) was used to obtain data from Scholar Google (https://scholar.google.com/) [37]. The keywords for searching publications were: ankle distraction arthroplasty, Ilizarov method articulation joint, distraction joint, arthrodiastasis ankle (Table 1). The broad search strategy is deliberately chosen, given the different names of the procedure in the 20th century, since the goal of a systematic review is to collect as much information about the procedure as possible.

***Table 1.*** *Search query structure.*

| Database | Search query | Number of publications |
|---|---|---|
| PubMed | "ankle distraction arthroplasty" OR "ilizarov method articulat* joint*" OR "distract* joint*" OR "arthrodiastas* ankle" OR "ankle distract*" | 3402 |
| Scopus | "ankle distraction arthroplasty" OR "ilizarov method articulat* joint*" OR "distract* joint*" OR "arthrodiastas* ankle" OR "ankle distract*" | 274 |
| Scholar Google | "ankle distraction arthroplasty" OR "ilizarov method articulat* joint*" OR "distract* joint*" OR "arthrodiastas* ankle" OR "ankle distract*" | 965 |

Search query data was exported using the built-in database functionality of PubMed and Scopus. Scholar Google search data was exported using the Publish or Perish application. Literature lists were also extracted from literature reviews found in the search process and, in the absence of these works in the final stage of the analysis, they were added (works from other sources).

**Remove duplicates.**

The collected data, including titles and annotations, were imported into a specialized Rayyan web application [38] for a systematic review by the research team. Using the de-duplication function of the Rayyan web application, followed by manual control, the final removal of duplicates by one researcher is performed.

**Screening.**

After that, the titles and abstracts of all publications were analyzed independently by two researchers [AL] and [DA]. Each work was assigned the value “include”, “exclude”, “maybe”. In controversial situations, a third researcher [AP] was involved to resolve conflicts. According to the compliance with the inclusion criteria, based on the title and abstracts of the articles, the selection of works was carried out for the analysis of full texts (2 stages of screening). From the remaining publications, the corresponding works were selected based on the analysis of the full text of the publication according to the inclusion criteria, using a similar methodology.

**Analysis.**

All selected publications are entered into a table in the Microsoft Excel spreadsheet. An assessment was made for the level of reliability. Based on the full texts of the articles, the following parameters were entered into the table: number of patients, average age, gender, classification of AOA, stage of AOA, cause of AOA, presence of deformities, type of device layout (hinged or fixed), presence of contracture, additional interventions (open/ arthroscopic debridement, use of cellular technologies, microfracturing, supramalleolar osteotomies, gastrocnemius lengthening, osteochondral autotransplantation, use of other technologies to restore cartilage, subtalar arthroeresis, calcaneal osteotomy, subtalar arthrodesis), pain before and after surgery, presence of pin site inflammation, the difference in range of motion before and after surgery, complications, number of patients with unsuccessful results (arthrodesis or arthroplasty in the observation period), size of arthrodiastasis, duration of treatment in EF, research results.

The data were entered by one researcher [AL], two other researchers independently checked the accuracy of the entered data [DA] and [AP]. In case of incorrectness of the filled information, their correction was carried out. If the interpretation of the data from the publication was ambiguous, the decision to enter the information was made collectively after discussion.

**Statistics.**

At each stage of the screening, a statistical test of agreement was performed Cohen's kappa coefficient.

**Assessment of methodological quality and risk of bias.**

The Joanna Briggs Institute Critical Appraisal tools for use in JBI Systematic Reviews was used to assess the methodological quality, internal and external validity of all included studies [39]. Checklists were used depending on the design of the study. The checklists include 8 to 13 questions that each item scored as one of “yes”, “no”, “unclear” or “not reported”. All quality assessment was performed by one primary and one secondary reviewers.

## Results.

At the search stage, 4640 publications from 3 sources were identified. After removing 400 duplicates, 4240 papers were received, which were included in the first stage of screening. 135 publications were selected, Cohen's kappa conformity 0.94. 135 publications were included in the 2nd stage of screening of full texts of materials. 32 articles were selected for analysis of the full texts of the articles, Cohen's kappa conformity 0.98. The algorithm for selecting articles is shown in Figure 2. No papers were added from other sources.

The analysis of the full texts of 32 publications was made, according to the parameters indicated earlier. Most of the studies in the study had a low level of evidence - IV (n=21, 65.6%). A total of 3 (9.38%) randomized clinical trials were included. From selected publications case report (n=12, 37.5%), case series (n=10, 31.25%), cohort studies (n=5, 15.63%), 2 (6.25%) cross-sectional and 2 prospective studies (Table 2).

Table 3 displays the scores from the risk of bias and methodological quality assessment for included studies. The 32 studies received a median the Joanna Briggs institute checklist score for RCT10/13 (range 6-10), cohort 6/11 (range 6-8), case series 5/10 (range 3-9), cross sectional 5/8 (range 4-6), case report 4/8 (range 2-6).

A total of 927 patients underwent ADA. The mean age of the patients was 44.9 ± 12.7 years. Among them, 230 (24.8%) left and 265 (28.6%) right ankle joints are among those studies in which this was indicated. Men 435 (46.9%) and women 463 (49.9%). Among the causes, post-traumatic AOA was indicated in 26 (81.3%) publications, osteochondral defects (n=2, 6.3%), consequences of poliomyelitis (n=4, 12.5%), congenital deformities (n=4, 12.5%), hemophilia (n= 2, 6.25%), idiopathic juvenile osteoarthritis (n=1, 3.1%), rheumatoid OA (n=1, 3.1%). Data on the ADA classification used were missing in 17

***Table 2.*** *Accepted studies for analysis.*

| Authors | Year | Title | Evidence | Design | Patients |
|---|---|---|---|---|---|
| Dabash et al. [40] | 2020 | Distraction arthroplasty in osteoarthritis of the foot and ankle | 4 | case report | 2 |
| Greenfield et al. [41] | 2019 | Ankle Distraction Arthroplasty for Ankle Osteoarthritis: A Survival Analysis | 4 | cohort | 144 |
| Belczyk et al. [42] | 2009 | A Case Report of a Simultaneous Local Osteochondral Autografting and Ankle Arthrodiastasis for the Treatment of a Talar Dome Defect | 4 | case report | 1 |
| D'Angelantonio & Schick [43] | 2013 | Ankle distraction arthroplasty combined with joint resurfacing for management of an osteochondral defect of the talus and concomitant osteoarthritis: a case report | 4 | case report | 1 |
| Liu et al. [44] | 2020 | Ankle distraction arthroplasty for the treatment of severe ankle arthritis: Case report, technical note, and literature review | 4 | case report | 1 |
| Leonchuk et al. [45] | 2021 | Ankle distraction arthroplasty using the Ilizarov external fixation and arthroscopy: first clinical experience | 4 | case report | 1 |
| Xu et al. [46] | 2017 | Ankle joint distraction arthroplasty for severe ankle arthritis | 4 | case series | 16 |
| Choi & Lui [47] | 2013 | Chondrolysis of the Ankle Joint following Ankle Arthroscopy and Microfracture of the Osteochondral Lesion of the Talar Dome | 4 | case report | 1 |
| Kaul & Prasad [48] | 2018 | Distraction arthroplasty for post traumatic osteoarthritis of the ankle joint: A case report | 4 | case report | 1 |
| Paley et al. [17] | 2008 | Distraction arthroplasty of the ankle--how far can you stretch the indication? | 4 | case series | 23 |
| Li et al. [49] | 2021 | The effect of joint distraction osteogenesis combined with platelet-rich plasma injections on traumatic ankle arthritis | 3 | cohort | 106 |
| Cleary et al. [50] | 2019 | Short-term outcome of surgical arthrodiastasis of the ankle with Ilizarov frame in a cohort of children and young people with juvenile idiopathic arthritis | 4 | case series | 8 |
| Sabharwal & Schwechter [51] | 2007 | Five-year follow-up of ankle joint distraction for post-traumatic chondrolysis in an adolescent: a case report | 4 | case report | 1 |
| Haelewijn et al. [52] | 2021 | Clinical and Biomechanical Progression after Ankle Joint Distraction in a Young Adolescent Patient with Haemophilia | 4 | case report | 1 |
| Ramanujam et al. [53] | 2010 | Subtalar joint arthrodesis, ankle arthrodiastasis, and talar dome resurfacing with the use of a collagen-glycosaminoglycan monolayer | 4 | case report | 1 |
| Ploegmakers et al. [54] | 2005 | Prolonged clinical benefit from joint distraction in the treatment of ankle osteoarthritis | 3 | case series | 22 |
| Marijnissen et al. [55] | 2002 | Clinical benefit of joint distraction in the treatment of severe osteoarthritis of the ankle: proof of concept in an open prospective study and in a randomized controlled study | 2,3 | RCT, prospective | 66 |
| Zhao et al. [56] | 2017 | Supramalleolar Osteotomy with Distraction Arthroplasty in Treatment of Varus Ankle Osteoarthritis With Large Talar Tilt Angle: A Case Report and Literature Review | 4 | case report | 1 |
| Nakasa et al. [14] | 2015 | Distraction arthroplasty with arthroscopic microfracture in a patient with rheumatoid arthritis of the ankle joint. | 4 | case report | 1 |
| Intema et al. [57] | 2011 | Subchondral bone remodeling is related to clinical improvement after joint distraction in the treatment of ankle osteoarthritis | 3 | case series | 26 |
| Zhang et al. [58] | 2017 | Comparison of distraction arthroplasty alone versus combined with arthroscopic microfracture in treatment of post-traumatic ankle arthritis | 3 | cohort | 96 |
| van Valburg et al. [59] | 1999 | Joint distraction in treatment of osteoarthritis: a two-year follow-up of the ankle | 4 | case series | 17 |
| Nozaka et al. [60] | 2020 | Effectiveness of distal tibial osteotomy with distraction arthroplasty in varus ankle osteoarthritis | 4 | case series | 21 |
| Tellisi et al. [61] | 2009 | Joint preservation of the osteoarthritic ankle using distraction arthroplasty | 4 | case series | 23 |
| Gianakos et al. [62] | 2020 | Effect of Microfracture on Functional Outcomes and Subchondral Sclerosis Following Distraction Arthroplasty of the Ankle Joint | 3 | cohort | 78 |

| | | | | | |
|---|---|---|---|---|---|
| Marijnissen et al. [63] | 2014 | Patient characteristics as predictors of clinical outcome of distraction in treatment of severe ankle osteoarthritis | 3 | cross-sectional | 111 |
| Nguyen et al. [64] | 2015 | Intermediate-term follow-up after ankle distraction for treatment of end-stage osteoarthritis | 4 | cross-sectional | 29 |
| Herrera-Pérez et al. [65] | 2019 | Debridement and hinged motion distraction is superior to debridement alone in patients with ankle osteoarthritis: a prospective randomized controlled trial | 1 | RCT | 25 |
| Saltzman et al. [18] | 2012 | Motion versus fixed distraction of the joint in the treatment of ankle osteoarthritis: A prospective randomized controlled trial | 1 | RCT | 36 |
| Van Meegeren et al. [66] | 2012 | Joint distraction results in clinical and structural improvement of haemophilic ankle arthropathy: A series of three cases | 4 | case series | 3 |
| Zhao et al. [15] | 2017 | Functional analysis of distraction arthroplasty in the treatment of ankle osteoarthritis | 3 | case series | 46 |
| Zhao et al. [67] | 2019 | Supramalleolar osteotomy with medial distraction arthroplasty for ankle osteoarthritis with talar tilt | 3 | cohort | 18 |

***Table 3.*** *Risk of bias and quality of evidence assessment of included studies. Numbers 1–13 in the first row refer to the equivalent items in the Joanna Briggs Institute checklist. T: total.*

| **Study** | **Design** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **T** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dabash, 2020 | case report | Y | N | Y | N | N | Y | N | N | - | - | - | - | - | 3/8 |
| Greenfield, 2019 | cohort | Y | Y | Y | N | N | N | N | Y | Y | Y | Y | - | - | 7/11 |
| Belczyk, 2009 | case report | N | N | N | Y | Y | N | N | Y | - | - | - | - | - | 3/8 |
| D'Angelantonio, 2013 | case report | Y | N | N | Y | Y | N | N | N | - | - | - | - | - | 3/8 |
| Liu, 2020 | case report | Y | N | N | N | Y | Y | Y | N | - | - | - | - | - | 4/8 |
| Leonchuk, 2021 | case report | Y | N | N | N | Y | N | Y | N | - | - | - | - | - | 3/8 |
| Xu, 2017 | case series | Y | Y | Y | Y | N | Y | Y | Y | Y | Y | - | - | - | 9/10 |
| Choi, 2013 | case report | Y | Y | N | N | N | N | N | N | - | - | - | - | - | 2/8 |
| Kaul, 2018 | case report | Y | N | Y | Y | Y | Y | Y | N | - | - | - | - | - | 6/8 |
| Paley, 2008 | case series | N | N | Y | N | N | N | N | Y | N | Y | - | - | - | 3/10 |
| Li, 2021 | cohort | Y | Y | Y | N | N | Y | Y | Y | Y | N | Y | - | - | 8/11 |
| Cleary, 2019 | case series | N | Y | N | N | N | N | N | Y | Y | Y | - | - | - | 4/10 |
| Sabharwal, 2007 | case report | Y | Y | N | Y | Y | Y | N | Y | - | - | - | - | - | 6/8 |
| Haelewijn, 2021 | case report | Y | Y | Y | Y | Y | N | N | N | - | - | - | - | - | 5/8 |
| Ramanujam, 2010 | case report | Y | N | Y | N | Y | N | N | Y | - | - | - | - | - | 4/8 |
| Ploegmakers, 2005 | case series | N | Y | Y | N | N | Y | Y | Y | N | Y | - | - | - | 6/10 |
| Marijnissen, 2002 | RCT | Y | N | N | N | N | N | Y | Y | N | Y | Y | Y | N | 6/13 |
| Zhao, 2017 | case report | Y | N | Y | Y | Y | Y | N | Y | - | - | - | - | - | 6/8 |
| Nakasa, 2015 | case report | Y | N | Y | Y | Y | Y | N | Y | - | - | - | - | - | 6/8 |
| Intema, 2011 | case series | Y | N | N | N | N | N | N | Y | N | Y | - | - | - | 3/10 |
| Zhang, 2017 | cohort | Y | Y | Y | N | N | N | Y | Y | N | N | Y | - | - | 6/11 |
| van Valburg, 1999 | case series | Y | Y | Y | N | N | Y | Y | Y | N | N | - | - | - | 6/10 |
| Nozaka, 2020 | case series | N | Y | Y | N | N | Y | Y | Y | N | Y | - | - | - | 6/10 |
| Tellisi, 2009 | case series | Y | Y | Y | N | N | N | N | Y | N | N | - | - | - | 4/10 |
| Gianakos, 2020 | cohort | Y | Y | Y | N | N | N | Y | Y | N | N | Y | - | - | 6/11 |
| Marijnissen, 2014 | cross-sectional | N | Y | N | Y | N | N | Y | Y | - | - | - | - | - | 4/8 |
| Nguyen, 2015 | cross-sectional | Y | Y | Y | Y | N | N | Y | Y | - | - | - | - | - | 6/8 |
| Herrera-Pérez, 2019 | RCT | Y | Y | Y | N | N | N | Y | Y | Y | Y | Y | Y | Y | 10/13 |
| Saltzman, 2012 | RCT | Y | Y | Y | N | N | N | Y | Y | Y | Y | Y | Y | Y | 10/13 |
| Van Meegeren, 2012 | case series | N | N | Y | N | N | N | N | Y | N | Y | - | - | - | 3/10 |
| Zhao, 2017 | case series | N | Y | Y | N | N | Y | Y | Y | N | Y | - | - | - | 6/10 |
| Zhao, 2019 | cohort | Y | Y | Y | N | N | N | Y | N | Y | N | Y | - | - | 6/11 |

***Table 4.*** *Additional interventions.*

| **Manipulations** | **Number of procedures** | **Publications** |
|---|---|---|
| Open arthrotomy | 151 (16.3%) | [17,18,40,41,42,43,44,46,53,56,61] |
| Ankle arthroscopy | 361 (38.9%) | [14,18,26,45,47,49,55,57,58,59,61,62] |
| Debridment | 509 (54.9%) | [14,15,17,18,26,40-49,53,55,57-59,61,62,67] |
| Microfracture | 143 (15.4%) | [14,15,17,40,41,44,45,47,53,58,62] |
| Supramalleolar osteotomy | 93 (10.03%) | [17,41,56,60,61,63,67] |
| Achilles lengthening<br>*(Hoke, Gastrocnemicus soleus release, Strayer)* | 58 (6.2%) | [17,26,40,41,46,61] |
| Intraarticular injection<br>*(BMAC, PRP, Growth hormone)* | 128 (13.8%) | [17,40,41,49,62] |
| Other manipulations:<br>Brostrom – 5 [67]<br>Calcaneal osteotomy – 3 [46,67]<br>Osteochondral autotransplantation – 1 [42]<br>Using collagen-glycosaminoglycan monolayer – 1 [53]<br>Arthroeresis – 1 [40]<br>Subtalus arthrodesis – 1 [53] | | |

*BMAC – Bone Marrow Aspirate Concentrate, PRP - Platelet-Rich Plasma*

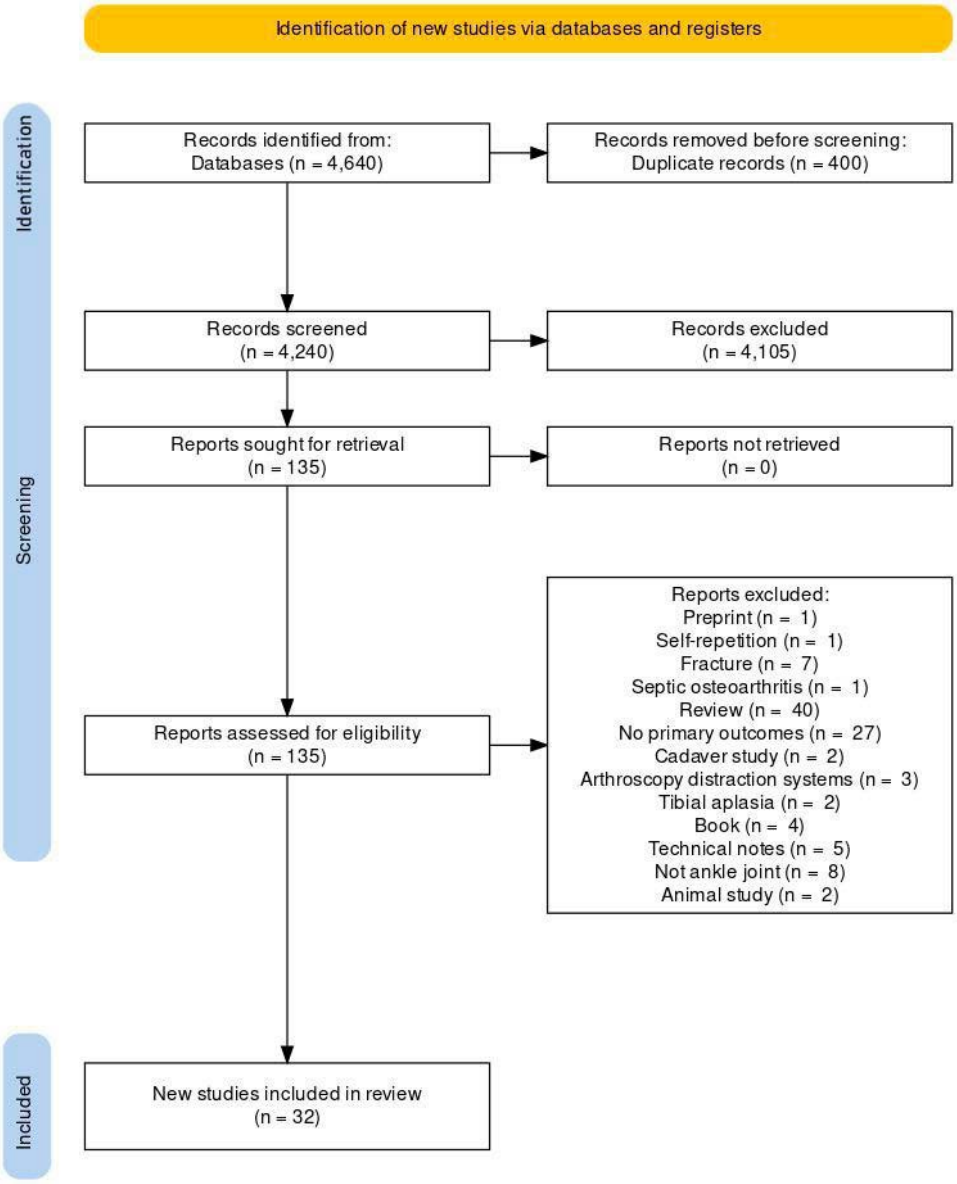



***Figure.2.*** *PRISMA flow diagram.*

(53.1%) articles, but all of them stated terminal or final stages. Other authors used the following classifications: Takakura (n=6, 18.8%), Kellgren-Lawrence (n=2, 6.2%), Outerbridge (n=2, 6.2%), Berndt-Harty (n=2, 6.2%), Giannini AO (n=1, 3.1%), Grade (n=1, 3.1%), Larsen (n=1, 3.1%), Petterson score (n=1, 3.1%), van Dijk (n=1, 3.1%). Accurate information about the number of patients with a specific stage of AOA, according to the described classifications, the presence of deformities, the presence of contracture of the ankle joint, is contained in a small number of works and represents an extremely variable description, so a correct generalization of the data is impossible.

The hinged modification was used in 22 (68.8%) studies, fixed in 13 (40.6%), it was not possible to establish the type of EF in 1 (3.1%) study (studies, where both modifications were used, are included in each of the groups). 646 patients (69.7%) were treated in hinged modifications and 171 (18.4%) in fixed modifications.

The mean evaluation period was 2.6 ± 2 years in all studies. All investigators report improvements in function and reductions in pain on various scales or as described by patients' overall well-being after the procedure. Given the extremely high diversity of data presentation, an unambiguous generalization in terms of results and pain reduction is not possible. An increase in range of motion (ROM) was reported in 16 (50%) papers. No data on ROM (n=10, 31.3%), no change in ROM (n=6, 18.8%). 1 (3.1%) study claims a reduction in ROM.

In total, 98 (10.5%) cases of conversion to arthroplasty or arthrodesis were indicated. Pin site infection was reported in 153 (16.4%) patients, but the majority of reports state that there are no serious complications without directly reporting it. Other complications included: breakage or need for new wires (n=21, 2.26%), complex regional pain syndrome (n=5, 0.5%), neuropathy (n=2, 0.21%), calf vein thrombosis (n=1, 0.1%). Additional surgical interventions are listed in Table 4.

The size of the achieved arthrodiastasis was not indicated in 5 (15.6%) studies. Arthrodiastasis 5 mm was used in 19 (59.4%) studies, 7 mm (n=2, 6.3%), 6-8 mm (n=1, 3.1%), 5-6 mm (n=1, 3.1%), 8 -10mm (n=1, 3.1%), 5.5mm (n=1, 3.1%), 6.2mm (n=1, 3.1%), 8-10mm (n=1, 3.1%), 10mm (n=1, 3.1%), 5.8 mm (n=1, 3.1%). The treatment period in the ANF was not specified in 5 (15.6%) studies. Treatment for a period of 12 weeks was used in 21 (65.6%) studies. Treatment period 10–12 weeks (n=4, 12.5%), 8 weeks (n=2, 6.3%), 15 weeks (n=1, 3.1%), 17 weeks (n=1, 3.1%).

Among the works that indicate the method of achieving arthrodiastasis, it can be divided into 3 types: one-stage intraoperative arthrodiastasis before reaching the planned interval (n=7, 21.9%), partial arthrodiastasis up to 3-4 mm, with the subsequent achievement of the planned up to 2 weeks after surgery (n=3, 9.4%), gradual creation of arthrodiastasis in the postoperative period by 0.5-1 mm per day (n=10, 31.3%). Regardless of the method of creating a planned arthrodiastasis, no serious complications were reported.

Among the analyzed 32 publications, the results of researchers differ significantly on the indications for ADA, the classifications used to assess AOA, the type of device (hinged or fixed), the rate of achievement and size of arthrodiastasis, the frequency of complications and conversions after ADA, postoperative management and rehabilitation, treatment outcomes, including their objective evaluation.

## Discussion.

The main limiting factor of our study is the low level of evidence of the work, the small number of samples, the lack of a detailed description of the patients with AOA included in the study, short-term and medium-term follow-up periods. Most of the articles contain a description of 1 patient, only 3 works describe groups of more than 100 patients. Many works do not contain objective evaluation criteria for outcomes of treatment outcomes, such as questionnaires, scales, and the like.

### Indications for ADA.

In most studies, the indications for ADA are AOA of the terminal or final stage, where patients were candidates for arthrodesis or total ankle replacement. The most commonly described use is in post-traumatic conditions but use in any etiology of AOA is acceptable. The presence of deformities, contractures, avascular necrosis, and talus collapse is not a direct contraindication but affects the effectiveness of the method [15,41,61,64]. The effect of age as a significant limiting factor was not found in the works. The presence of subchondral sclerosis does not affect the level of pain. The role of the pain syndrome is associated with subchondral cysts, which regress and thicken after the use of ADA. [57].

**External fixators designs and additional interventions.** There have been reports of broken pins when using EF arrangements that use pins passed through the bones of the tarsus or metatarsus [55,59].

Fixed EF design has a medium-term positive effect on survival (preservation of the native joint) [64]. Research claims better early functional outcomes and greater survival of hinged EF models, including those with randomized clinical trials [18,63,64].

Micro fracturing of cartilage defects has a positive effect but increases the time to return to previous activity [14,58,60,62]. It is worth noting the lack of randomization of patients in the studies. The need to perform micro fracturing indicates greater severity of the damage. One paper argues that there are no benefits to performing microfracture [62].

Additional intra-articular application of cellular technologies (BMAC, PRP) improves functional results and accelerates the recovery of the previous activity [49,62].

When comparing ADA with isolated arthroscopic debridement in the preterminal stages of AOA, it has a statistically significant effect in reducing pain in the medium-term follow-up periods [26,55]. Randomized trial claims no effect of debridement on pain levels and range of motion at 2 years between hinged and fixed EF designs [18].

When combined with supramalleolar osteotomy (SMO), there are no differences in function, pain level, range of motion, or conversion rate compared with isolated SMO. The statistically significant difference in talar tilt angle, which is better in the combined treatment group [67].

The most common treatment period with ADA is 12 weeks. When combined with SMO, the treatment period lasts until the formation of a bone union. A study by Bernstein et al.

recommends a treatment period of 8 to 12 weeks, claiming no benefit beyond 12 weeks of treatment [11].

A cadaver study by Fragomen et al. recommends a minimum arthrodiastasis level of 5.8 mm to maintain full disengagement of the articular surfaces under full load in the EF [19]. It is worth noting that the load mode varies greatly in the works we analyzed, from no load at all to full load.

**Postoperative management.**

In different studies, the development of movements with the use of articulating devices begins the next day, or 2–3 weeks after the operation, after reaching the required level of arthrodiastasis. Most of the works do not indicate an explicit program for the rehabilitation of patients. Hinged motion is carried out without axial load (lying or sitting). There are several descriptions of rehabilitation regimens: 15 repetitions 4 times a day [40], 15 repetitions 3 times a day or more [43] or 20 repetitions 3 times a day, including with the use of an expander [18].

Postoperative antibiotic prophylaxis uses 5- or 7-day courses after surgery. In most studies, antibiotic prophylaxis in the postoperative period is not indicated. The use of antibiotics in the event of inflammation in the pin site has been reported.

Thromboprophylaxis, if indicated, was performed within 3–4 weeks from the date of surgery. Injections of low molecular weight heparins were used for it. Most studies do not explicitly indicate thromboprophylaxis.

Control of arthrodiastasis of the planned size, if indicated, was performed using weight-bearing radiographs or intraoperative fluoroscopy. The regimen of control X-ray examinations to confirm the maintenance of arthrodiastasis is not described.

**Treatment outcomes and their estimate.**

As a result of ADA, pain reduction without radical surgery was noted by 56% of 16 patients after 40 months [46], 98.11% of 53 patients after 6 months [49], more than 2/3 of 111 patients after 5 years, and 66% by 12 years [63], 55% of 29 patients at 5 years [14], 74% and 59% of 25 patients at 3 and 5 years, respectively [26].

The female gender has been described as a risk factor for failure within 2 years of the procedure [41,63]. The presence of the hinged modification eliminated the effect of this factor [63]. Most often, conversion to arthrodesis or arthroplasty is described in the first 1–3 years after dismantling of the EF. Lack of significant improvement after treatment is a highly likely conversion factor by the end of year 1 [64].

Analyzing the data on the survival of patients after DAHS, we can judge the following relative contraindications to ADA: body mass index > 28 kg/m^2 [15], talar tilt > 5 degrees [15], avascular necrosis [41], AOS (Ankle Osteoarthritis Scale) before surgery > 42 points (the lower the better) [64], the presence of valgus or uncorrected deformity [61].

There are no reports of complications and difficulties during subsequent arthrodesis or total ankle replacement after ADA [1 5,17,18,26,41,46,50,54,58,61,59,62,64].

## Conclusion.

Despite the more than 50-year history of ADA, there is still no sufficient understanding of this methodology. The goal of future research is to understand the exact indications for ADA depending on the stage, etiology, and type of AOA.

The ADA technique (device type, size, speed of distraction, treatment time) varies depending on the author using it, and further data accumulation is required to develop an understanding of the effectiveness of various method variations. ADA allows for combined cartilage and joint interventions that can stimulate cartilage regeneration or restore normal joint anatomy. In addition, the creation of unified protocols for describing patients who have undergone ADA will allow a more detailed understanding of this treatment method in the future.

ADA is a promising effective method of treatment that allows achieving an improvement in function and a reduction in pain in the medium and long term while preserving the patient's joint.

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