



Surgical correction of pes planovalgus deformity in ankle osteoarthritis: clinical and functional outcomes

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Abstract

Introduction Pes planovalgus is a progressive, collapsing deformity of the foot, stage IV (subtype IV B according to the Myerson classification), associated with ankle joint involvement. This pathology remains one of the most complex and disabling in foot and ankle surgery. Surgical correction of the hindfoot associated with ankle osteoarthritis suggests careful planning and may include isolated arthrodesis procedures and strategies to be followed by total ankle arthroplasty.

The **objective** was to evaluate the clinical and functional results of surgical correction of pes planovalgus deformity in patients with concomitant ankle osteoarthritis.

Material and methods This retrospective, single-center study included data from 13 surgically treated patients with stage IVB flatfoot deformity and concomitant ankle osteoarthritis. All patients underwent surgery to correct the hindfoot deformity, using various arthrodesis procedures depending on the clinical situation. Clinical and functional outcomes were assessed using the visual analog scale (VAS), the AOFAS scale, and the FAOS questionnaire before and after surgery. The minimum follow-up period was 12 months. Statistical analysis was performed using the Wilcoxon signed-rank test with exact two-tailed *p* values calculated.

Results Postoperatively the median VAS score decreased from 8 [7; 8] to 2 [2; 3.5] scores (*p* = 0.000244). The median FAOS score increased from 22 [16.5; 42] to 86 [69; 89.5] (*p* = 0.001709). The median AOFAS score improved from 40 [32.5; 42.5] to 88 [80; 90] (*p* = 0.000977).

Discussion The findings are consistent with those reported in international literature and demonstrate the high efficacy of hindfoot arthrodesis in this condition. Significant improvement in the functional parameters suggests the appropriateness of the surgical approach. In some cases, hindfoot arthrodesis can be considered as the first step prior to the total ankle arthroplasty.

Conclusion Surgical correction of pes planovalgus deformity through hindfoot arthrodesis provides a statistically significant reduction in pain and improved functional status in patients with concomitant ankle osteoarthritis.

Keywords: pes planovalgus, ankle osteoarthritis, subtalar arthrodesis, total ankle replacement, AOFAS, clinical outcomes

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INTRODUCTION

Flat-valgus foot deformity in adults is a progressive and potentially disabling musculoskeletal disorder characterized by collapse of the medial longitudinal arch of the foot with valgus deviation of the hindfoot and abducted forefoot, combined with pronation of the midfoot. In modern international literature, the term "progressive collapsing foot deformity" (PCFD) is used to denote this condition. This term was proposed by a consensus group of experts headed by Myerson in 2020 as the one that most fully reflects the three-dimensional and progressive nature of the pathological process [1]. The Johnson – Strom classification (1989), supplemented by Myerson in 1997, is more common in Russian clinical practice. It grades four stages of deformity with stage IV as the most severely involved ankle joint [2, 3].

There are primary degenerative, post-traumatic, and inflammatory forms of involvement among degenerative diseases of the lower limb joints with each requiring an independent diagnostic and treatment algorithm [4]. Ankle osteoarthritis (OA) differs in the etiology from lesions of the knee and hip joints. According to modern research, 70 % to 80 % of cases of ankle OA are post-traumatic, with the deformity being idiopathic in the remaining cases (primary degenerative) [5]. Hallux valgus is associated with abnormal biomechanics, increasing the load on the medial ankle joint with progressive cartilage destruction, and deltoid ligament insufficiency is often a key factor in the development of talus valgus, as confirmed by clinical observations of surgical correction of hindfoot valgus [6, 7]. This relationship explains the high incidence of combined pathology (flat-valgus foot deformity and ankle OA) in patients aged 50 and over; degenerative lesions of the foot joints in this age group are often polysegmental [8].

Surgical treatment of patients with Myerson stage IVB PCFD accompanied by ankle OA remains technically challenging with a limited evidence base. Current recommendations suggest ankle arthrodesis or total ankle arthroplasty (TAA) in combination with correction of foot deformity. A staged strategy can be employed in some cases: arthrodesis of the hindfoot is performed at the first stage to eliminate deformity and normalize biomechanics, and TAA is performed at the second stage [9, 10]. The importance of correcting the deformity before TAA is confirmed by data on long-term implant survival: Burkov et al. reported the 10-year survival rate of TAA of 77–87.5 % in a systematic review, and the authors suggested unrepaired axial deformities as a factor in reducing implant survival [11]. The PCFD Consensus Group emphasizes that priority is given to preserving joint mobility where possible with the strategy, however, arthrodesis is the method of choice in cases of rigid posterior deformity and the presence of subtalar joint OA [12].

Good functional outcomes of subtalar and double subtalar arthrodesis are reported for various indications, including hindfoot deformities. Dutra et al. reported in a systematic review the average AOFAS scored 44 and 79 before and after arthrodesis, respectively ($p < 0.001$) [13]. However, there is a paucity of clinical and functional outcomes reported in the Russian literature regarding a cohort of patients with concomitant ankle OA including deformative and degenerative components of the pathology.

The **objective** was to evaluate the clinical and functional results of surgical correction of pes planovalgus deformity in patients with concomitant ankle OA.

MATERIAL AND METHODS

This was a retrospective, single-center study. The analysis included data from 13 patients (13 feet) with flatfoot and associated ankle involvement surgically treated at the Orthopedics Department of City Clinical Hospital No. 31 named after Academician G.M. Savelyeva, which is the clinical site of the Department of Traumatology and Orthopedics of the RUDN University Institute of Medicine. The minimum postoperative follow-up period was 12 months.

Inclusion criteria. The study included patients aged 18 and over with clinically and instrumentally confirmed adult acquired flatfoot deformity (Myerson AAFD Stage IV B) accompanied by signs of ankle OA. Inclusion criteria included surgical correction of the hindfoot deformity and a complete clinical and functional examination before and after surgery.

Non-inclusion criteria. The study did not include patients with rheumatoid arthritis, neuroarthropathy (Charcot foot), severe vascular pathology of the lower extremities, idiopathic flatfoot without signs of PCFD graded by Myerson, and cases without complete clinical observation in the postoperative period.

The study cohort included 13 clinical cases (13 feet). The median age was 62 [55; 69.5] years. By etiology, post-traumatic deformity was predominant (Table 1).

Hindfoot deformity was surgically corrected in the patients. Depending on the clinical situation, arthrodesis procedures performed included subtalar arthrodesis and double arthrodesis (talocalcaneal and talonavicular joints). Ankle arthrodesis (tibiotalar arthrodesis) was produced in two cases. Total ankle arthroplasty was performed in one patient during the second stage of treatment, 3 years after subtalar arthrodesis (see clinical case). The extent of surgical intervention was determined individually based on the clinical presentation and radiographic data. Joint fixation was performed with cannulated compression screws.

Clinical and functional outcomes were assessed preoperatively and at postoperative follow-up. Pain intensity was assessed using the visual analogue scale (VAS, 0–10 scores). Foot and ankle function were assessed using the American Orthopaedic Foot and Ankle Society Ankle–Hindfoot Score (AOFAS, 0–100 scores) and Foot and Ankle Outcome Score (FAOS, 0–100 scores).

Statistical data processing was performed using standard methods of variation statistics in IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA). Quantitative indicators are presented as median and interquartile range, Me [Q1; Q3], as well as mean and standard deviation, $M \pm SD$. The exact Wilcoxon signed-rank test for related samples was used to compare indicators before and after surgical treatment. Differences were considered statistically significant at a significance level of $p < 0.05$.

Table 1

Age, gender and clinical characteristics of patients
($n = 13$)

Description		Value	
Age, years	(Me [Q1; Q3])	62 [55; 69.5]	
	($M \pm SD$)	63,0 $\pm$ 7,8	
		aбс.	%
Gender	Female	9	69.2
	Male	4	30.8
Side of involvement	Left	8	61.5
	Right	5	38.5
Etiology of the deformity	Post-traumatic	9	69.2
	Degenerative	4	30.8

Note: Me is the median; Q1, Q3 are the lower and upper quartiles; M is the mean; SD is the standard deviation. Quantitative data are presented as Me [Q1; Q3] and $M \pm SD$.

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Informed consent was obtained from all patients for the publication of information and images in a scientific article.

RESULTS

The median VAS scored 8 [7; 8] at baseline, indicating severe pain. Postoperatively, the VAS score decreased significantly compared to the preoperative level: median 2 [2; 3.5] scores (Wilcoxon test, $T = 0$; $p = 0.000244$). The relative reduction in median pain was 75 %.

The FAOS score was 22 [16.5; 42] at baseline, indicating severe functional deficit. Post-treatment, the FAOS score increased significantly compared to baseline: median 86 [69; 89.5] scores ($T = 4$; $p = 0.001709$). The median FAOS score increased by 64.

The pre-op AOFAS scored 40 [32.5; 42.5], which corresponded to a poor functional condition. A statistically significant improvement in the AOFAS score after treatment was revealed: a median of 88 [80; 90] scores ($T = 1$; $p = 0.000977$). Thus, the increase in the AOFAS scored 48 by median points with the majority of patients having good and excellent results. A comparative assessment of the clinical and functional indicators before and after surgical treatment is presented in Table 2.

Table 2

Comparative assessment of clinical and functional scores before and after surgical treatment

Description	Pre-op, Me [Q1; Q3]	Post-op, Me [Q1; Q3]	T (Wilcoxon)	<i>p</i>
VAS, score	8 [7; 8]	2 [2; 3.5]	0	0.000244
FAOS, score	22 [16.5; 42]	86 [69; 89.5]	4	0.001709
AOFAS, score	40 [32.5; 42.5]	88 [80; 90]	1	0.000977

Note: Me is the median; Q1, Q3 are the lower and upper quartiles; T is the exact statistic of the Wilcoxon signed-rank test (sum of the ranks of the smaller group, W- or W+); VAS — Visual Analogue Scale; FAOS — Foot and Ankle Outcome Score; AOFAS — American Orthopaedic Foot and Ankle Society Ankle–Hindfoot Score.

Clinical case

A 54-year-old female patient with bilateral involvement was diagnosed with stage IVB flat-valgus foot deformity, post-traumatic osteoarthritis of the subtalar and ankle joints. The injury occurred eight years ago. The first stage of treatment included subtalar arthrodesis of the left foot (2020) performed as a staged intervention to correct the deformity and normalize biomechanics in the context of progressive osteoarthritis of the ankle joint. Scores at baseline included VAS of 8, AOFAS of 45. Preoperative radiometry measurements included MDTA = 98°, TTA = 93°, Tilt = 5° at baseline and MDTA = 90°, TTA = 90°, Tilt = 0° after completion of both stages of surgical treatment.

With a stable bone fusion achieved and the deformity stabilized three years later (in 2023), total ankle arthroplasty (stage two) was performed. This case illustrates the validity of a two-stage approach for severe concomitant ankle osteoarthritis in patients with planovalgus deformity (Fig. 1).



Fig. 1 Radiographs of the patient's feet at stages of surgical treatment of planovalgus deformity and osteoarthritis of the ankle joint: (1) pre-op, lateral view; (2) pre-op, AP view; (3) post-op, lateral view; (4) post-op, AP view; (5) after the first stage of surgical treatment, lateral view; (6) after the first stage of surgical treatment, AP view; (7) after the second stage of surgical treatment, lateral view; (8) after the second stage of surgical treatment, AP view

DISCUSSION

The results obtained in this study demonstrate statistically significant and clinically relevant improvements in the three assessment scores (VAS, FAOS, and AOFAS) after surgical correction of planovalgus deformity in patients with ankle osteoarthritis. The increase in AOFAS from a median of 40 to 88 scores, and in FAOS from 22 to 86 scores suggests transition of most patients from the poor to good and excellent functional status, which is consistent with the results of international cohort studies.

Dutra et al. performed a systematic review and reported the mean AOFAS increasing from 44 to 79 scores ($p < 0.001$) after subtalar arthrodesis in 180 patients with a mean follow-up period of 18 months [13]. In our series, the median AOFAS scored 88 post-op, which is slightly higher than the values described in the literature. This may be due to differences in patient selection, timing of follow-up examinations, and the surgical techniques used. Some authors suggest limitations of the AOFAS scale as an unvalidated instrument and recommend its use in combination with validated PROMS, such as FAOS. In Russian practice, the AOFAS scale is used as part of comprehensive postoperative rehabilitation protocols [14].

A significant reduction in pain measured with the VAS (from a median of 8 to 2 scores) is consistent with the results reported by Bernasconi et al. on subtalar arthrodesis for subtalar joint degeneration: a significant improvement in functional and anatomical parameters was observed in 33 patients with a median age of 62 years [15]. Interestingly, the age and demographic profile of our cohort (median age 62 years, predominance of females) is almost identical to that in this study, which increases the comparability of the results.

The high proportion of post-traumatic etiology in our cohort (69.2 %) is consistent with epidemiological data: Valderrabano et al. and Rungprai et al. reported 70 to 80 % of ankle osteoarthritis being caused by previous trauma in the general population [5]. In the remaining cases, the deformity is idiopathic (primary degenerative), which was also observed in our cohort: four out of 13 patients (30.8 %) had a degenerative etiology of planovalgus deformity without indications of previous trauma. Post-traumatic deformities are normally characterized by more severe degenerative damage to the articular surfaces and require more extensive arthrodesis. This is precisely what determined the use of double subtalar arthrodesis in a significant proportion of patients in the study group.

In the presented clinical example, the patient with post-traumatic osteoarthrosis of the ankle joint was treated with subtalar arthrodesis as the first stage in order to correct the deformity and optimize biomechanical conditions for subsequent total ankle arthroplasty. The strategy is gaining increasing recognition. It is emphasized that the foot deformity should be corrected first in the presence of severe foot deformity and osteoarthrosis of the ankle joint since uncorrected deformity can lead to eccentric loading on the prosthetic components and early aseptic loosening [3, 12, 16]. According to Burkova et al. reported a systematic review of 13,859 primary ankle arthroplasties with non-repaired axial deformities as one of the main reasons for revision interventions, the frequency of which averaged 12.9 % over 19 years of observation [11].

TAA and ankle arthrodesis in end-stage osteoarthritis was compared in the multicentre randomised controlled trial TARVA (2023) demonstrated comparable improvements in quality of life, however neither group included patients with non-corrected foot deformity [17], supporting the need for a stepwise approach.

Limitations of the study

First, the retrospective design and small sample size ($n = 13$) preclude generalizability; the results should be interpreted with caution given the potential for patient selection bias. Second, the lack of a control group precludes comparison with alternative treatments. Third, a 12-month follow-up period is the minimum for assessing long-term outcomes and the progression of associated osteoarthritis.

The ***advantages of the study*** include the use of validated (FAOS) and widely used (AOFAS, VAS) assessment tools; their reliability and reproducibility have been confirmed in specialized psychometric studies [18, 19]. The AOFAS scale is used as the main tool for the quantitative assessment of the clinical and functional results of reconstructive interventions on the foot [20]. An analysis of the results of the clinical subgroup of stage IVB PCFD with ankle osteoarthritis was conducted; the treatment of this nosology is insufficiently covered in the Russian literature. The findings can be compared with data on earlier stages of PCFD [21] and form the basis for planning prospective multicenter studies with a longer follow-up period.

Clarification of diagnostic staging criteria within the PCFD classification, including verification of the deformative and degenerative components, remains a priority to improve the homogeneity of the compared cohorts [22]. Preoperative planning, including radiographic assessment of deformity parameters and articular cartilage condition, is of fundamental importance for choosing the optimal scope of intervention during foot reconstruction [23]. The role of hindfoot instability in the progression of degenerative changes in the ankle joint is confirmed by data from Russian

studies. Thus, optimization of the lateral calcaneal extension osteotomy technique based on CT scan results in the Russian population demonstrates the importance of precise positioning of bone structures for restoring normal load distribution in the tibiotalar joint [24].

The use of custom-made implants allows for expanded indications for TAA in complex multi-stage reconstructions in cases of severe talar bone deficiency [25]. Systematization of historical and contemporary approaches to treating patients with planovalgus deformity suggests that conservative and surgical methods continue to evolve with more personalized and functionally oriented strategies [26]. Diagnostic imaging methods, including MRI and CT, play a key role in determining the extent of degenerative lesions of the ankle joint and adjacent structures of the hindfoot which would be associated with the choice of surgical strategy [27]. Comparison of long-term results of isolated subtalar arthrodesis shows that, when the indications and technical conditions of the surgery are followed, a lasting satisfactory result can be achieved in the majority of patients [28]. Russian experience with an individualized approach to the level of osteotomy of the calcaneus in flat-valgus deformity, based on 3D modeling, demonstrates an improvement in the AOFAS scores and radiographic parameters after 12 months of observation [29], which correlates with the results of our study.

A comparison of double subtalar arthrodesis combined with talonavicular arthrodesis and calcaneal displacement osteotomy showed comparable functional outcomes with similar complication profiles, suggesting that both approaches are equivalent in the appropriate clinical situations [30]. Double versus triple arthrodesis would be controversial in more severe lesions involving the talocalcaneal, talonavicular, and calcaneocuboid joints. A prospective comparative study by Fadle et al. found no significant differences in functional outcomes [31]. Subtalar arthrodesis demonstrates satisfactory functional results in patients with posttraumatic subtalar joint osteoarthritis following calcaneal fractures with the underlying fracture pattern having a significant impact on outcome [32].

An algorithm for postoperative patient care after ankle arthroplasty, including rehabilitation protocols and complication monitoring, has been developed and verified using Russian clinical data [33]. It should be emphasized that the accumulated experience of reconstructive interventions for foot deformities in pediatric patients cannot be extrapolated to adult patients due to fundamental differences in pathogenesis and surgical approaches [34].

CONCLUSION

Surgical correction of flatfoot deformity through arthrodesis of the hindfoot (subtalar arthrodesis, double arthrodesis) provides statistically significant improvement in clinical and functional parameters in patients with concomitant ankle osteoarthritis. The findings demonstrate the effectiveness of the surgical approach. A staged approach can be recommended in cases of severe ankle osteoarthritis: the first stage involves correction of the hindfoot deformity to be followed by total ankle arthroplasty (if necessary) and rehabilitation with a strict postoperative management protocol.

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