MIDTERM SEVERE FOREFOOT DEFORMITY TREATMENT OUTCOMES IN ELDERLY PATIENTS

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Severe complex deformities of the forefoot in elderly patients with no rheumatoid arthritis result in the pronounced decrease in quality of life, chronic pain, reduced mobility, failure to get shoes for everyday use, exacerbation of the concomitant somatic diseases. The use of conventional joint preservation techniques in such patients often leads to the deformity relapse, persistent pain, and the need for revision surgery that is often impossible due to worsening of the patients' general somatic status and local functional status. The study was aimed to improve surgical outcomes in elderly patients with no rheumatoid arthritis who had severe forefoot deformities. The prospective cohort study that involved allocation to the retrospective group for comparison of surgical outcomes in 65 patients was carried out in 2016–2019. The results obtained before and after surgery were assessed using the FFI, AOFAS Hallux, and AOFAS Lesser Toes scores. The Maryland scores were used to assess the outcomes during the postoperative period. The study revealed significant differences in treatment outcomes based on the AOFAS Hallux (p = 0.0001), AOFAS Lesser Toes (p = 0.0001), FFI (p = 0.0001), and Maryland (p = 0.0001) scores. In view of the elderly patients' specific nature, the radical surgical techniques that do not ensure joint preservation may be considered as effective and predictable methods of correction aimed at reducing the rate of revision surgeries. These techniques represent a one-step method to improve the quality of life of elderly patients.

Keywords: flat-valgus foot, metatarsalgia, forefoot

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Compliance with ethical standards: the study was approved by the Ethics Committee of Pirogov Russian National Research Medical University (protocol No. 181 of 28 January 2018). All patients submitted the informed consent to study participation.

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СРЕДНЕСРОЧНЫЕ РЕЗУЛЬТАТЫ ЛЕЧЕНИЯ ТЯЖЕЛОЙ ДЕФОРМАЦИИ ПЕРЕДНЕГО ОТДЕЛА СТОПЫ У ПАЦИЕНТОВ ПОЖИЛОГО ВОЗРАСТА

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Комплексные тяжелые деформации переднего отдела стопы у пожилых пациентов, не страдающих ревматоидным артритом, характеризуются выраженным снижением качества жизни, формированием хронического болевого синдрома, снижением общей мобильности с невозможностью подбора обуви для ежедневного использования, усугублением течения сопутствующих соматических заболеваний. Использование классических, сохраняющих сустав техник у данных пациентов зачастую приводит к рецидиву деформации, стойкому сохранению болевого синдрома, необходимости ревизионных вмешательств, часто невозможных из-за усугубления общесоматического или местного статуса пациента. Целью исследования было улучшить результаты хирургического лечения пациентов пожилого возраста, не страдающих ревматоидным артритом, с тяжелой деформацией переднего отдела стопы. Проведено проспективное когортное исследование с выделением ретроспективной группы сравнения результатов оперативного лечения 65 пациентов, с 2016 по 2019 г. Результаты до и после операции оценивали по шкалам FFI, AOFAS Hallux, AOFAS Lesser Toes. Оценку результатов в послеоперационном периоде проводили по шкале Maryland. В исследовании получены статистически значимые различия результатов лечения по шкалам AOFAS Hallux (p = 0,0001), AOFAS Lesser Toes (p = 0,0001), FFI (p = 0,0001), Maryland (p = 0,0001). В связи со специфичностью пожилых пациентов радикальные методики, не сохраняющие сустав, могут быть рассмотрены как эффективный предсказуемый способ коррекции, направленный на сокращение ревизионных вмешательств, и являются одноэтапным методом улучшения качества жизни пожилых пациентов.

Ключевые слова: плоско-вальгусная деформация, метатарзалгия, передний отдел стопы

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Surgical treatment of elderly patients with forefoot deformities is a challenging task. The static complex deformity that involves deformities of two or more rays of the foot together with severe hallux valgus and rigid lesser ray deformities is difficult to correct by conventional surgical methods.

When developing the treatment tactics, it is necessary to take into account not only the foot deformity and the bone tissue quality together with the features of selecting metal fixators [1], but also the neurocirculatory status of the limb, local functional status of the soft tissues, the presence and course

of chronic concomitant disorders,taking various medications in order to ensure compensation, the need to minimize the patient's hypodynamia, his/her social status and ability to adequately execute the more or less complex postoperative instructions [2].

It is worth choosing more predictable tactics of surgical correction in order to minimize the risk of the deformity relapse, chronic pain, and the need for revision surgical interventions.

Regardless of numerous options for correction of severe static complex forefoot deformities, there is still no consensus on management of elderly patients [3]. The currently existing treatment tactics are often based on the surgeon's personal experience only [4].

Given high perioperative risk, it is recommended to use conservative therapy in many elderly patients. However, conservative treatment of patients with no risk of surgical intervention fails to restore the patients' motor activity or improve their quality of life. Furthermore, it is often impossible due to high cost and inaccessibility of orthopaedic devices [5]. Moreover, some authors note the increased injury rate in elderly patients that is associated with alterations of gait stereotype due to severe foot deformities [6], while surgical treatment makes it possible to restore the patients' freedom of movement and improve their quality of life despite all the risks [7].

Regarless of the fact that satisfactory forefoot deformity treatment outcomes can be generally achieved by surgical correction, the share of adverse outcomes is still high (25–33%) [8]. It would be several times higher in the group of elderly patients, that is why the revision surgery rate would also increase.

The attempts to correct severe deformities in these patients by conventional joint preservation techniques often lead to failure because of the morphological features of persistent deformity, such as severe cicatricial adhesion of the sesamoids, which cannot be corrected without aggressive loosening of soft tissues, the need for pronounced lateralization of the first metatarsal distal fragment and the failure of fixation due to osteoporosis of various origins and minimal bone contact after the bone fragment displacement, because of the high risk of the first metatarsal head avascular necrosis associated with abnormal vascularization, development of severe degenerative arthrosis of first metatarsophalangeal joint after correction due to underestimation of the initial injury to the cartilage and subchondral bone [9]. All of this leads to progressive first ray deformity and abnormalities of the stance and pushoff phase [10], incomplete PASA correction, and the development or recurrence of pre-existing transfer metatarsalgia [11], the development of extensive soft tissue damage associated with abnormal circulation due to massive releases [12], symptomatic pseudarthrosis [13]. The rigid dislocations of the lesser toe proximal phalanges with the contracture formation and shortening of the toe neurovascular bundles increase the risk of tissue necrosis and toe gangrene after the dislocation management involving insufficient shortening of the ray [14]. The degenerative damage to the fixing soft tissue structures, sich as the plantar plate and the collateral ligaments of metatarsophalangeal joints increase the intraoperative time and the soft tissue injury when attempting to restore these structures using grafting or suture, while lesser metatarsal osteotomy often results in symptomatic pseudarthrosis with severe metatarsalgia [15].

All the above circumstances result in the need to rely on more predictable surgical methods and the methods that make it more likely to avoid revision surgery and provide radical treatment to rid the patient of symptoms when choosing the surgical treatment tactics for this extremely complex group of patients. The radical surgical technique that does not ensure joint preservation that has been first proposed for treatment of patients with rheumatoid arthritis is one of such methods.

The study was aimed to improve surgical outcomes in elderly patients with no rheumatoid arthritis who had severe forefoot deformities using the surgical technique that did not ensure joint preservation.

METHODS

Study design

The prospective cohort study that involved allocation to the retrospective group for comparison of surgical outcomes in patients who received treatment at the Department of Traumatology, Orthopedics and Military Field Surgery (Pirogov Russian National Research Medical University) and the University Clinic of Traumatology and Orthopedics (City Clinical Hospital № 1, Moscow) was carried out in 2016–2019. The average period of the treatment outcome estimation in the control group was 34.26 ± 9.48 months, while the average period of the treatment outcome estimation in the index group was 27.73 ± 6.31 months.

All the patients were operated by the same surgical team under spinal anesthesia. The follow-up examination of the patient after surgery was conducted by the surgical team members at weeks 6, 12, 24 after surgery and during the patient's last visit. The post-surgical instrumental examination of the feet that involved the forefoot radiography in the anteroposterior and oblique projections was also performed at weeks 6, 12, 24 and during the patient's last visit.

Patients

The study involved 65 patients, among them all were females. This can be explained by predominance of symptomatic foot deformities in women. The average age of the studied patients was 72.69 ± 5.54 years.

Inclusion criteria: age over 65 years; no established diagnosis of rheumatoid arthritis; severe first ray foot deformity according to the Coughlin classification; rigid hammertoe deformity of one or more lesser toes with dislocation of the metatarsophalangeal joint that cannot be fixed during clinical assessment; no clinical effects of conservative therapy.

Exclusion criteria: age under 65 years; history of surgical correction of the forefoot; mild-to-moderate first ray foot deformity according to the Coughlin classification; elastic deformities of the lesser toes.

Reconstructive surgery of single foot was performed in all groups. The patients were divided into two groups in accordance with the applied technique.

The control patients were operated using the conventional joint preservation techniques. The control group included 35 patients.

The following surgical methods were considered as conventional.

Correction of the first ray of the foot in the control group:

– distal metadiaphyseal osteotomy of the first metatarsal (SCARF, Chevron, Maestro);

– Akin osteotomy of the great toe proximal phalanx;

– Lapidus procedure;

– metatarsophalangeal joint resection arthroplasty.

The correction options were used in combinations (Table 1).

Correction of the lesser rays of the foot in the control group was performed by the following methods:

Table 1. Characteristics of the first ray surgeries

Characteristics of methods	Total number of patients	Number of cases, abs	Share of cases, %
Distal osteotomies + Akin osteotomy	35	22	62.9%
Lapidus procedure + distal osteotomy	35	16	45.7%
Metatarsophalangeal joint resection arthroplasty	35	5	14.3%

– distal minimally invasive metatarsal osteotomy (DMMO);

– Weil osteotomy without bone fixation in accordance with our patented method (RF patent No. 2705233);

– Weil osteotomy with bone fixation;

– resection arthroplasty of the proximal interphalangeal joints of the lesser toes (Table 2).

Patients of the index group (n = 30) were operated using the technique that did not ensure joint preservation known as the Hoffman-Clayton procedure, which included arthrodesis of the first metatarsophalangeal joint, 2^{nd}–5^{th} metatarsal head resection, resection arthroplasty of the proximal interphalangeal joints involving transcutaneous fixation of the 2^{nd}–5^{th} toes with wires in the metatarsal canals, or using our patented method (RF patent № 2742447), which included arthrodesis of the first metatarsophalangeal joint and fixation with a plate, 2^{nd}–4^{th} metatarsal head resection, resection arthroplasty of the proximal interphalangeal joints involving transcutaneous fixation of the 2^{nd}–4^{th} toes with wires in the metatarsal canals, minimally invasive oblique proximal diaphyseal osteotomy of the fifth metatarsal without metal fixation.

Postoperative management of patients

On day two after surgery the patient was bandaged to ensure elastic toe fixation in the position of metatarsophalangeal joint overcorrection (plantar flexion) in the control group or the position set by metal fixators in the index group.

On day 14 the dressings were changed and the stitches were removed from the postoperative wound, the patient was bandaged again to ensure the position of metatarsophalangeal joint overcorrection till day 28 after surgery. After that the dressings were removed in both groups. In the index group the fixing wires were also removed on day 28 after the intervention.

All the parients were allowed the operated limb loading since the next day after surgery using special orthopedic shoes. The guidelines on wearing orthopedic shoes varied depending on the type of the first metatarsal reconstructive surgery type. Shoes had been used for 6 weeks after distal osteotomy or for 8 weeks after the first metatarsophalangeal joint arthrodesis and the Lapidus procedure.

Methods for assessment of the results

The following preoperative and postoperative radiological parameters were assessed:

– hallux valgus angle (HVA; the angle between the longitudinal axes of the first metatarsal and the first proximal phalanx of the hallux);

– intermetatarsal angle (IMA; the angle between the longitudinal axes of the first and second metatarsals);

– proximal articular set angle (PASA; the angle formed by the articular surface of the first metatarsal head and the longitudinal axis of the first metatarsal).

The function of the foot was assessed before and after surgery using the folowing scores: FFI (Foot Functional Index), AOFAS (American Orthopaedic Foot and Ankle Society Score) Lesser Toes, AOFAS (American Orthopaedic Foot and Ankle Society Score) Hallux. The results were also assessed using the Maryland score during the postoperative period.

According the the results obtained (Table 3), there were no significant intergroup differences in the main preoperative assessment criteria. However, it should be noted that statistical processing has revealed differences in the PASA and IMA scores. This can be explained by errors of positioning for radiography and small size of the patient sample.

Statistical analysis

When comparing two groups based on the numerical indicators, the mean values and standard deviations were used in the M ± S format. The nonparametric Mann–Whitney U test was used to compare two groups by quantitative variables. Statistical significance of intergroup differences for binary and categorical variables was defined using the Pearson's chi-squared (χ^2) test. Analysis of the dependent variables for comparison of two periods was based on the nonparametric Wilcoxon signed-rank test. The significance level was set at 0.05. Statistical data processing was performed using the Statistica 10 and SAS JMP 11 software packages.

RESULTS

The data obtained (Table 4) suggest that there were significant differences in all the indicators between two comparison groups. The most significant were the differences in the FFI scores between the controls and the index group (on average by 26.0%; $p < 0.0001$); the AOFAS Lesser Toes scores between the index group and the controls (on average by 33.1%; $p < 0.0001$); the AOFAS Hallux scores between the index group and the controls (on average by 19.6%; $p < 0.0001$).

The analysis of the dynamic changes in these parameters before and after treatment is provided in Table 5.

The findings suggest that all the indicators have changed significantly. The most significant are the changes in the FFI scores (in the control group) (on average by 34.5%; $p < 0.0001$); the AOFAS Lesser Toes scores (in the control group) (on average by 29.9%; $p < 0.0001$); the AOFAS Hallux scores (in the control group) (on average by 43.0%; $p < 0.0001$).

Statistical processing has also revealed the risk factors that most often lead to satisfactory and adverse treatment

Table 2. Characteristics of the main lesser ray surgeries

Characteristics of methods	Total number of patients	Number of cases, abs	Share of cases, %
DMMO	35	6	17.1%
Weil osteotomy without bone fixation	35	17	65.4%
Weil osteotomy with bone fixation	35	9	34.6%
Resection athroplasty	35	26	74.3%

Table 3. Comparison of two groups based on the radiological criteria and foot function assessment results obtained using the assessment scales before surgery

Indicator	Group		Significance level *p*
	Control group	Index group	
	(*n* = 35)	(*n* = 30)	
Scores			
AOFAS Hallux before surgery	18.77 ± 11.44	16.03 ± 5.80	0.8312
AOFAS Lesser Toes before surgery	19.63 ± 13.61	18.10 ± 5.86	0.4009
FFI before surgery	68.74 ± 12.93	72,87 ± 12,66	0.2009
Radiological criteria			
HVA before surgery	54.26 ± 6.55	55.67 ± 9.13	0.7366
IMA before surgery	19.77 ± 1.99	17.93 ± 2.79	0.0055
PASA before surgery	33.60 ± 7.61	37.57 ± 7.05	0.0168

outcomes based on the AOFAS Hallux, AOFAS Lesser Toes, FFI scores of the control group obtained before surgery.

The AOFAS Hallux and AOFAS Lesser Toes scores below 75 were considered as satisfactory and adverse treatment outcomes. The FFI scores above 40% were considered as satisfactory and bad.

Significance of the indicator effects on the target binary variable was determined using the Pearson's chi-squared (χ^2) test. All the factors were sorted in descending order of significance (χ^2 statistics) to select the key indicators of the risk of such events, as AOFAS Hallux < 75, AOFAS Lesser Toes < 75, FFI > 40.

Age over 70 appeared to be a significant risk factor in all the studied groups.

AOFAS Lesser Toes — $p = 0.0005$

AOFAS Hallux — $p = 0.03$

FFI — $p = 0.002$

DISCUSSION

The world literature describes numerous options for surgical correction of severe valgus forefoot deformities and various conbinations of methods. However, selection of options for correction does not take into account the patient's age, circulatory status of the limb, the partient's rehabilitation potential, and concomitant disorders. Decompensation of concomitant disorders often makes it impossible to perform revision surgery, thus leading to persistence of pain syndrome, decrease in the elderly patient's daily activity, reduced quality of life, and the need for continuous use of anti-inflammatory drugs. Elimination of pain and prevention of the foot deformity relapse are the main goals of the surgical treatment of severe deformities in elderly patients. Thus, it has been shown that cosmetic results were less important than elimination of pain and the possibility to increase the distance traversed [16]. It is necessary to chose more controllable, predictable, and reliable methods of surgical correction to ensure elimination of pain in this group of patients. Arthrodesis of the metatarsophalangeal joint and lesser metatarsal head resection are one of the options for severe forefoot deformities in patients with rheumatoid arthritis. This procedure that does not ensure joint preservation allows to achieve persistent elimination of pain, radical correction of the deformity, and the increase in the patient's daily activity.

However, a few sources assume that surgical treatment of this type can also be suitable for correction of severe rigid forefoot deformities in elderly patients.

Thus, assessment of 13 patients (15 feet; the average follow-up period was 44.3 months after surgery; the range was 20–76 months) showed that the average postoperative satisfaction score was 9.0 (out of 10) [17]. None of the patients in this cohort needed reoprative surgery. The pain score was significantly reduced: from 6.2 before surgery to 1.9 after surgery ($p < 0.001$). Radiological parameters (1.2 IMA, HVA) improved after surgery ($p < 0.05$), the first metatarsophalangeal joint arthrodesis union was achieved in all 15 feet.

In the retrospective study of 39 patients (56 feet) with severe non-rheumatic forefoot deformities, 13 patients (20 feet) underwent first metatarsophalangeal joint arthrodesis and lesser metatarsal head resection, 20 patients (26 feet) underwent first metatarsophalangeal joint arthrodesis and Weil osteotomy of the metatarsal [18]. The average follow-up period was 24 months. The criteria of the patients' condition after surgery were assessed using the AOFAS and SF-36 scores. Postoperative satisfaction was 92% in patients after first metatarsophalangeal joint arthrodesis and lesser metatarsal head resection and 91% in patients after first metatarsophalangeal joint arthrodesis and lesser metatarsal osteotomy. However, the quantity of revision surgeries was not estimated in the studied groups. The total SF score was 80.7 and 76, respectively. The researchers concluded that surgery of this type could be recommended

Table 4. Comparison of two groups based on the radiological criteria and foot function assessment results obtained using the assessment scales after surger

Indicator	Group		Significance level *p*
	Control group	Index group	
	(*n* = 35)	(*n* = 30)	
Scores			
AOFAS Hallux after surgery	61.80 ± 13.99	81.40 ± 4.54	< 0.0001
AOFAS Lesser Toes after surgery	49.49 ± 13.76	82.60 ± 3.34	< 0.0001
Maryland MFS	67.49 ± 7.02	88.40 ± 3.45	< 0.0001
Maryland MFS	34.20 ± 12.59	8.20 ± 4.62	< 0.0001
HVA after surgery	26.20 ± 8.32	12.93 ± 5.53	< 0.0001
IMA after surgery	11.20 ± 2.49	12.67 ± 2.35	0.015

Table 5. Estimation of the dynamic changes in the studied criteria before and after surgery

Group	Indicator	M ± S, before	M ± S, after	Dynamic changes	Differences between mean values (before –after)	Significance level *p*
Control group	AOFAS Hallux	18.77 ± 11.44	61.80 ± 13.99	229.22%	43.03	< 0.0001
Control group	AOFAS Lesser Toes	19.63 ± 13.61	49.49 ± 13.76	152.11%	29.86	< 0.0001
Control group	FFI	68.74 ± 12.93	34.20 ± 12.59	–50.25%	–34.54	< 0.0001
Control group	HVA	54.26 ± 6.55	26.20 ± 8.32	–51.71%	–28.06	< 0.0001
Control group	IMA	19.77 ± 1.99	11.20 ± 2.49	–43.35%	–8.57	< 0.0001
Control group	PASA	33.60 ± 7.61	21.06 ± 4.93	–37.33%	–12.54	< 0.0001
Index group	AOFAS Hallux	16.03 ± 5.80	81.40 ± 4.54	407.69%	65.37	< 0.0001
Index group	AOFAS Lesser Toes	18.10 ± 5.86	82.60 ± 3.34	356.35%	64.5	< 0.0001
Index group	FFI,	72.87 ± 12.66	8.20 ± 4.62	–88.75%	–64.67	< 0.0001
Index group	HVA	55.67 ± 9.13	12.93 ± 5.53	–76.77%	–42.74	< 0.0001
Index group	IMA	17.93 ± 2.79	12.67 ± 2.35	–29.37%	–5.26	< 0.0001

for treatment of chronic pain associated with severe non-rheumatic forefoot deformities.

In the retrospective study of 193 patients of whom 85 were elderly people, all patients underwent examination 6 months and 2 years after surgery [19]. Conventional surgical techniques for correction of deformities, such as SCARF osteotomy of first metatarsal, osteotomy of the proximal phalanx of the hallux (Akin osteotomy), and the lesser metatarsal Weil osteotomy, were used in all the patients. No significant differences in postoperative satisfaction between the cohorts of young, middle-aged, and elderly patients were revealed based on the AOFAS and Sf-36 scores. However, it should be noted that the number of bed-days in the hospital was higher in elderly patients than in other groups, the return visits due to pain in the opreated feet and hospital readmissions were more frequent in the group of elderly patients. The most important fact was that the group of elderly patients had a 5 times higher risk of the deformity relapse.

In our study, the index group included 30 patients, all the them were operated using the proposed method or our patented method (RF patent № 2742447).

The treatment outcomes were assessed using the AOFAS Lesser Toes, AOFAS Hallux, FFI, Maryland scores, the average follow-up period was 27.73 ± 6.31 months. In the intervention group, we managed to ensure a significant increase in the AOFAS Hallux score (from 16.03 ± 5.80 to 81.40 ± 4.54); the average increase for the parameter was 65.37; the AOFAS Lesser Toes score increased from 18.10 ± 5.86 to 82.60 ± 3.34, the average increase for the parameter was 64.5; as for the FFI score, we managed to improve the foot function from 72.87 ± 12.66% to 8.20 ± 4.62% (average values), the improvement was 64.67% (average values). When assessing the foot function after surgery, the average Maryland score was 88.40 ± 3.45, which corresponded to beneficial outcome. We managed to ensure significant differences in treatment outcomes compared to the control group based on the AOFAS Lesser Toes, AOFAS Hallux, FFI, Maryland scores. None of the patients needed revision surgery due to recurrent metatarsalgia or transfer metatarsalgia, hallux valgus relapse, rigid hammertoe deformity, osteotomy or arthrodesis non-union.

The described treatment outcomes, patients' satisfaction, and no need for revision surgery were achieved due to rational selection of the surgical technique for correction of static complex forefoot deformities in this extremely complex group of elderly patients. All the operated patients stayed mobile throughout the postoperative period, which was extremely important for elderly people. After surgery the daily activity levels and the maximum distance traveled without pain improved in all patients; the patients faced no difficulties when selecting footwear for everyday use, it was no longer necessary to select or purchase the highly complex orthopedic shoes.

CONCLUSIONS

The proposed option for correction of static complex forefoot deformities in elderly patients can be used in clinical practice. Despite its radical nature, the option has made it possible to achieve persistent elimination of pain, reduce the risk of reoperative surgery, and restore mobility in elderly patients with no rheumatoid arthritis.

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