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Determination of the risk of obtaining unsatisfactory results of surgical treatment of patients with static deformities of the forefoot when using various surgical approaches

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The main method of treatment of static deformations of the forefoot (SDPVS) is surgical. The most static deformities of the foot in its front part most often include valgus deformity of the first toe — Hallux valgus (HV), hammer-like deformities of 2–4 toes, and Taylor's deformity. Objective. To assess the effectiveness of surgical treatment of SDPVS and to determine the risk of obtaining an unsatisfactory result with different surgical approaches. Methods. The treatment of 565 patients (1009 feet) was analyzed, the main group — 729 feet, control 280 feet. The groups of patients differed in the methods of surgical treatment of deformities of the forefoot. The choice of surgical intervention in the main group was carried out according to the algorithmized system of surgical treatment of patients with SDPVS. Results. The results of treatment of patients with static deformities of the front part of the foot in the main group were significantly (p < 0.001) better than the results in the control group of patients. In the main group, good results accounted for 55.0 % of cases, satisfied — 39.2 %, unsatisfactory — 5.8 %, compared to the control group — 26.1 %, 43.2 and 30.7 %, respectively. The reduction of the relative risk of obtaining an unsatisfied result (RRR) in the main group when using the proposed algorithmized system of treatment of SDPVS is 68 %. In the treatment of combined VDPPS with deformities of 2–5 toes, the risk of an unsatisfactory result is higher compared to isolated VDPPS in both groups. The risk of an unsatisfactory treatment result in patients with combined HV deformity and deformities of 2–5 toes in the control group is 15.9 % higher (RR = 0.159 ± 0.174) than in the main group. The use of the proposed approach to the selection of surgical treatment tactics based on the developed algorithmized system of surgical treatment of SDPVS can reduce the relative risk of obtaining unsatisfactory treatment results by 84 % (RRR = 0.841).

Основним методом лікування статичних деформацій переднього відділу стопи (ДПВС) є хірургічний. Здебільшого до викривлень саме цієї локалізації найчастіше відносять вальгусну деформацію першого пальця стопи (ВДППС) — Hallux valgus (HV), молоткоподібні деформації 2–4 пальців стопи та деформацію Тейлора. Мета. Оцінити ефективність хірургічного лікування статичних деформацій переднього відділу стопи та визначити ризик отримання незадовільного результату за різних хірургічних підходів. Методи. Проаналізовано лікування 565 пацієнтів (1 009 стоп), Основна група — 729 стоп, контрольна — 280 стоп. Групи пацієнтів відрізнялися методами хірургічного лікування ДПВС. Вибір оперативного втручання в основній групі проводили згідно з алгоритмізованою системою хірургічного лікування пацієнтів із статичними ДПВС. Результати. Ефект від лікування у пацієнтів зі статичними ДПВС в основній групі значущо (p < 0,001) кращий ніж у контрольній. В основній групі на частину добрих результатів припадає 55,0 % випадків, задовільних — 39,2 %, незадовільних — 5,8 %, у порівнянні з контрольною — 26,1 %, 43,2 та 30,7 %, відповідно. Зниження відносного ризику отримання не задовільненого результату (RRR) в основній групі за умов використання запропонованої алгоритмізованої системи лікування статичних ДПВС складає 68 %. За лікування комбінованої ВДППС із деформаціями 2–5 пальців стопи ризик виникнення незадовільного результату вище в порівнянні з ізольованою ВДППС в обох групах. Ризик виявлення не задовільного результату лікування в пацієнтів із комбінованою деформацією HV та викривленнями 2–5 пальців стопи в контрольній групі на 15,9 % вище (RRR = 0,159 ± 0,174), ніж в основній групі. Висновки. Використання запропонованого підходу до вибору тактики хірургічного лікування на підставі розробленої алгоритмізованої системи хірургічного лікування статичних ДПВС може знизити відносний ризик отримання незадовільних результатів лікування на 84 % (RRR = 0,841). Ключові слова. Деформація переднього відділу стопи, Hallux valgus, молоткоподібні деформації пальців стопи, деформація Тейлора.

Keywords. Forefoot deformity, Hallux valgus, hammertoe deformities, Taylor’s deformity

Introduction

The main method of treatment of static forefoot deformities (FD) is surgical. For the most part, deformities of this location most often include valgus deformity of the first toe — *Hallux valgus* (HV), hammer-like deformities of the 2nd–4th toes, and Taylor's deformity.

In general, a fairly large number of the most diverse methods of surgical correction of its components have been proposed for the surgical treatment of static FD. So, if G. A. Albrecht [1] counted 11 operations in 1911, today there are more than 400 surgical techniques [2]. Such a large number of different methods of operative treatment, proposed for the correction of FD, may also indicate that this problem remains relevant today.

Purpose: to evaluate the effectiveness of surgical treatment of static deformities of the forefoot and to determine the risk of obtaining an unsatisfactory result with different surgical approaches.

Material and methods

The study was conducted, discussed and approved at a meeting of the Bioethics Committee at the State Establishment Professor M. I. Sytenko Institute of Spine and Joint Pathology of the National Academy of Sciences of Ukraine (Protocol No. 236 dated 13.11.2021). The treatment of 565 patients (1,009 feet) who were divided into main and control groups was assessed. The main group included 405 (729 feet) patients, the control group — 160 (280 feet). The control group consisted of patients who were treated according to the method developed at the institute in 1978 and which was used for their treatment until 2010 [3]. Groups of patients differed in the methods of surgical treatment of FD, but were similar in gender, age, and degree. This, in turn, made it possible to correctly compare the results of surgical interventions with the use of different treatment methods.

In the main group of 405 patients (729 feet), isolated valgus deformity of the first toe was diagnosed in 79 patients (148 feet), in 308 patients (552 feet) it was combined with curvatures of the 2nd–5th toes, in 12 patients (19 feet) with isolated hammer-like deformity of the 2nd–4th toes without FD, and in 6 patients (10 feet) with isolated Taylor deformity also without FD.

The control group consisted of 160 patients (280 feet) with FD, while in 110 patients (188 feet) it was combined with deformities of the 2nd–5th toes, and isolated in 50 people (92 feet). Isolated deformations of the 2nd–4th toes or the 5th toe were not observed.

In the main group, the following surgical interventions were performed: Schade operation, tenocapsulotomy of the 1st metatarsophalangeal joint, Akin osteotomy of the main phalanx of the first toe, Shevron osteotomy, Scarf osteotomy, wedge-shaped proximal osteotomy with screw or plate fixation, double distal and proximal osteotomy, Lapidus arthrodesis of the 1st metatarsal joint, resection of the main phalanx of the 2nd–4th toes according to Hohmann, Weil osteotomy of the 2nd–4th metatarsal bones, Helal osteotomy of the 2nd–4th metatarsal bones, distal wedge osteotomy of the 2nd–4th metatarsal bones, Shevron and Weil osteotomy of the 5th metatarsal bone, proximal wedge osteotomies of the 5th metatarsal bone. We chose exactly these methods of surgical intervention. Due to the prevalence of their use, they have a certain evidence base, most modern orthopedists consider them effective during the treatment of static FD.

The choice of one or another surgical intervention is determined by the clinical and biomechanical studies carried out in the biomechanics laboratory of the Institute, which made it possible to develop an algorithmized system of surgical treatment of patients with static FD (Figs. 1, 2).

In the control group of patients, the following surgical interventions were applied: Schade operation, tenocapsulotomy of the 1st metatarsophalangeal joint, wedge-shaped proximal osteotomy with fixation with spikes and transosseous fixation of the 1st and 5th metatarsal bones between themselves with an auto tendon for HV correction, resection of the main Hohmann phalanges of the 2nd–4th toes for correction of hammertoe deformity of the 2nd–4th toes, and proximal wedge-shaped osteotomies of the 5th metatarsal bone to correct Taylor deformity.

Evaluation of the results of surgical treatment was carried out according to the AOFAS scale [4] for the front part of the foot. Given the shortcomings of this scale, it was supplemented with clinical and radiological indicators. That is, a pain-free foot with the possibility of using ordinary shoes was considered a good result, the AOFAS score was 75–100 points. During the X-ray, the preserved correction of the deformity, the absence of any deformities, complications, and the patient's satisfaction with the functional and cosmetic result of the intervention were observed.

A satisfactory result was defined as a pain-free foot, or the presence of minor non-permanent pain syndrome with the following signs: violation of the contact of the toes with the surface of the support, the need to use additional orthopedic devices, and 51–74 points according to the AOFAS scale. During radiography, preserved correction, the absence

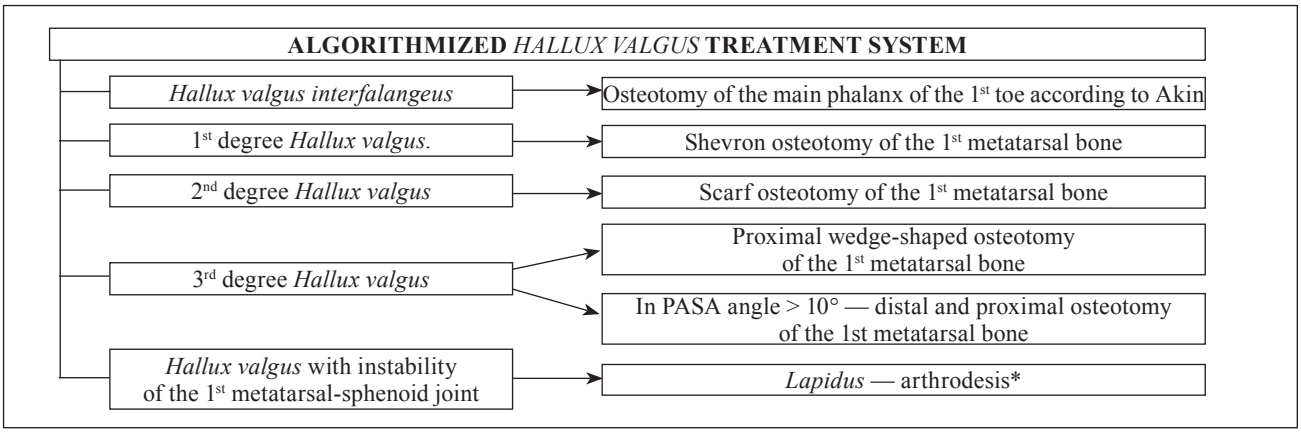

Fig. 1. Algorithmized system for choosing the tactics for surgical treatment of *Hallux Valgus.*
* Akin osteotomy for additional *Hallux valgus* correction

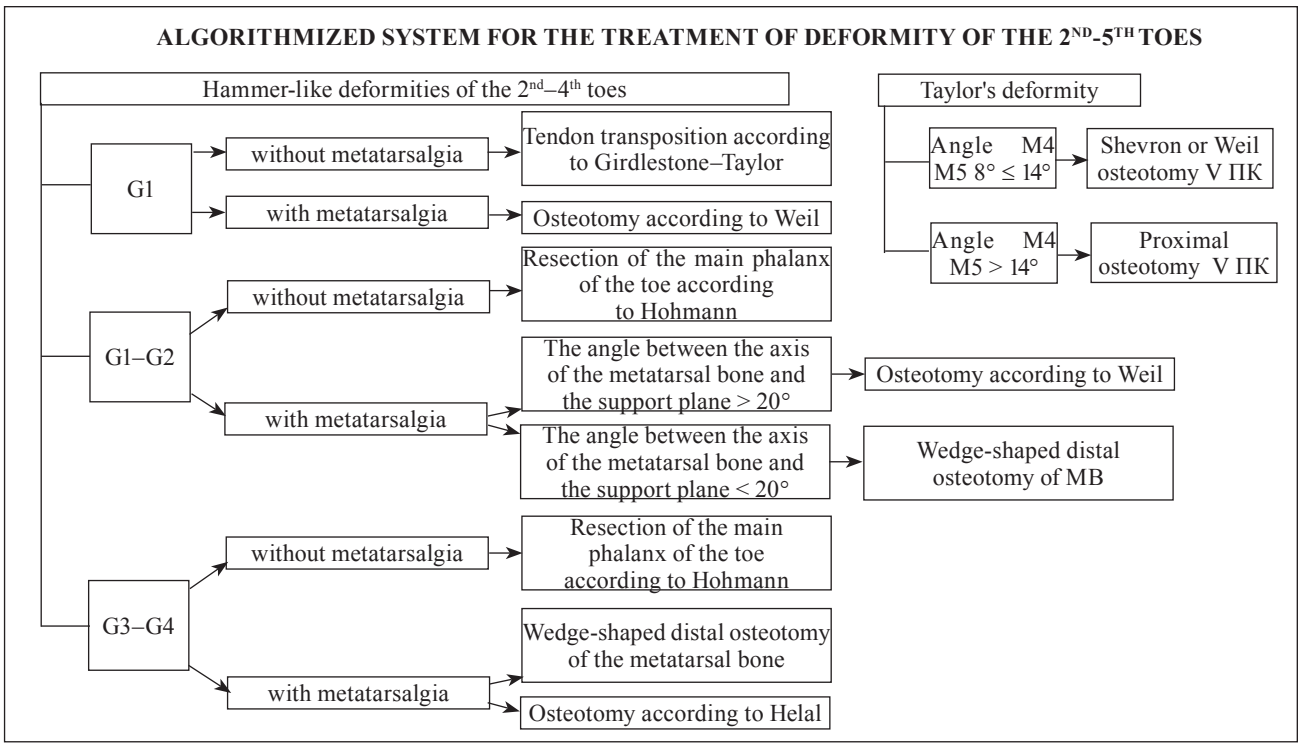

Fig. 2. Algorithmized system for choosing the tactics for surgical treatment of deformities of the 2nd-5th toes

of any residual deformations and complications, and the patient's satisfaction with the functional and cosmetic result were diagnosed.

Unsatisfactory treatment results were recorded in the presence of pain syndrome in the foot, recurrence of deformity or other iatrogenic distortions, loss of achieved clinical and radiological correction of the deformity, the need to use orthopedic shoes, complications after surgery, 50 points or less according to the AOFAS score, dissatisfaction of the patient with the obtained functional and cosmetic result.

Surgical evaluation was performed in 565 patients (1,009 feet). Patients who did not undergo control examinations were not included in the study. Each group was divided into 2 clusters — isolated and combined FD, where *Hallux valgus* curvature was combined with deformity of the 2nd–5th toes. Each cluster was divided into groups according to the degree of deformation.

In the control group, there were no HVI (*Hallux valgus interphalangeus*) deformities, isolated Taylor deformities and hammer-like curvatures of the toes, these feet were not included in the comparative analysis. Fig. 3 shows the algorithm for removing objects from the analysis and their distribution.

The results of surgical treatment of patients of the main and control groups within the same abnormalities were compared. Considering that the indicators belong to the nominal type, the algorithms of the conjugation tables were used. The analysis was performed according to the Chi-square (χ^2) criterion. Provided that the number of expected indicators less than 5 exceeded 30%, the calculation was carried out according to the Kramer V (V_{kr}) criterion.

Risk assessment was performed for the main and control clusters within the groups for isolated and combined HV with curvatures of the 2nd–4th toes. The absolute (R), relative risks (RR), its error (SE), as well as the limits of the 95 % confidence interval (95 % CI) of the relative risk were calculated [5]. Calculations were performed in IBM Statistic SPSS 20.0 and MS Excel environment.

Results

The results of surgical intervention of patients (with isolated HV are shown in Table 1.

According to the data of the statistical analysis, during the treatment of the deformation of HV Ist. no statistical difference (p = 0.408) was found between the options of surgical approaches.

During the treatment of 2nd degree HV impairment the results were assessed as good in 58 (56.3 %) patients and satisfactory in 45 (43.7 %), there were no unsatisfactory results. There were 38 (69.1 %) good results in the main group, and 20 (41.7 %) in the control group. Therefore, the groups differed statistically significantly (p = 0.0058).

For surgical treatment of the 3rd degree HV no unsatisfactory results were recorded either. In the main group, 42 (68.9 %) had statistically significant (p = 0.001) better results, compared to the control group, where there were 12 (33.3 %). Accordingly, satisfactory results of treatment prevailed in the control group — 26 (66.7 %).

Analysis of HV treatment showed 2 (100 %) cases with an unsatisfactory result due to the instability of the metatarsal-sphenoid joint. In the main group, there were mostly good results — 8 (80 %) and satisfactory results — 2 (20.0 %). The difference, respectively, between the groups was statistically significant (p = 0.002) in favor of the main group.

Considering that there are very few investigated cases of deformation of the 1st degree HV (3 patients of the control group) and HV with instability of the metatarsal-sphenoid joint (2 persons of the control group and 10 of the main group), the evidence of the calculations is not sufficient (Table 2).

Generalized analysis of the results of operations with isolated HV deformation showed a prevalence of good treatment results in the main group — 98 (69.4 %), which was almost twice (1.8 times) more

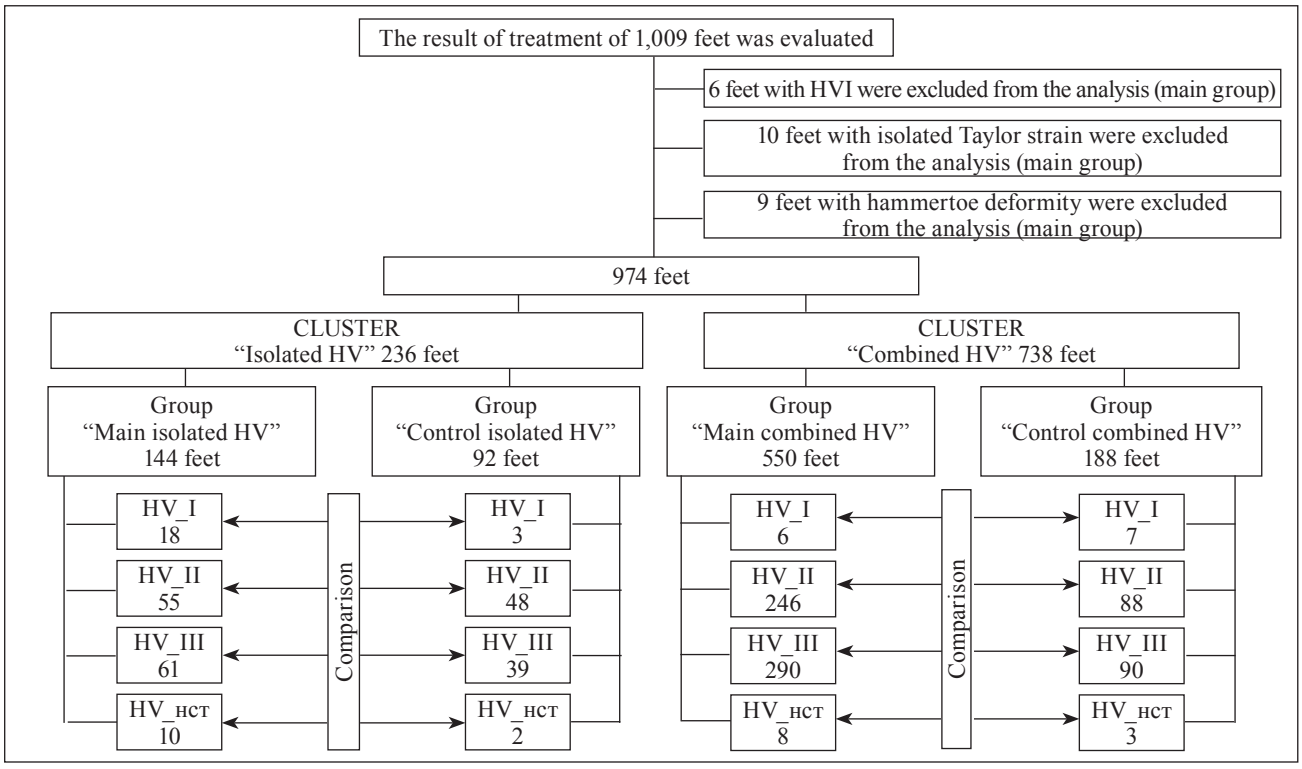

Fig. 3. The algorithm for selecting objects for the analysis of the effectiveness of surgical intervention and the procedure for statistical analysis

Table 1

Isolated valgus deformity of the 1st toe

Group	Result		
	good	satisfactory	unsatisfactory
1st degree *Hallux valgus*.			
Total (n = 18)	12 (66.7 %)	5 (27.8 %)	1 (5.6 %)
Control (n = 3)	1 (33.3 %)	2 (66.7 %)	—
In total (n = 21)	13 (61.9 %)	7 (33.3 %)	1 (4.8 %)
Statistical significance of the difference	V_{kr} = 0.292; p = 0.408 *		
2nd degree *Hallux valgus*.			
Total (n = 55)	38 (69.1 %)	17 (30.9 %)	—
Control (n = 48)	20 (41.7 %)	28 (58.3 %)	—
In total (n = 103)	58 (56.3 %)	45 (43.7 %)	—
Statistical significance of the difference	χ^2 = 7.836; p = 0.005		
3rd degree *Hallux valgus*.			
Total (n = 61)	42 (68.9 %)	19 (31.1 %)	—
Control (n = 39)	13 (33.3 %)	26 (66.7 %)	—
In total (n = 100)	55 (55.0 %)	45 (45.0 %)	—
Statistical significance of the difference	χ^2 = 12.127; p = 0.001		
Hallux valgus due to instability of the metatarsal-sphenoid joint			
Total (n = 10)	8 (80.0 %)	2 (20.0 %)	—
Control (n = 2)	—	—	2 (100.0 %)
Statistical significance of the difference	V_{kr} = 1.000; p = 0.002 **		

Notes: — in 66.7 % the expected frequency was less than 5, Kramer V criterion was used;*
*** — in 83.3 % the expected frequency was less than 5, Kramer V criterion was used*

Table 2

Results of surgical treatment of patients with isolated HV

Group	Result		
	good	satisfactory	unsatisfactory
Total (n = 144)	100 (69.4 %)	43 (29.7 %)	1 (0.7 %)
Control (n = 92)	34 (37.4 %)	56 (61.5 %)	2 (1.1 %)
In total (n = 233)	134 (57.4 %)	99 (42.4 %)	3 (1.2 %)
Statistical significance of the difference	χ^2 = 23.458; p < 0.001		

than in the control group — 34 (37.4 %), respectively, satisfactory results prevailed in the last group — 56 (61.5 %) compared to 43 (29.7 %) cases in the main one. Unsatisfactory results were recorded in 3 cases — 1 (0.7 %) in the control group and 2 (1.1 %) in the main group.

Unsatisfactory results in the main group were observed due to nonunion of the Shevron osteotomy, which required reoperation. In the control group, 2 feet in one patient were found to have recurred HV caused by instability of the metatarsal-sphenoid joint, which was not corrected during the intervention.

Analysis of the results of surgical treatment of patients with combined HV and deformities of the 2nd-5th toes revealed that in the control group compared to the main one, HVi deformities (2 feet), isolated Taylor deformities (10 feet) and hammertoe deformities (19 feet) were absent in the control group, therefore, the comparison was not carried out for them.

The results of treatment for this disorder in the main and control groups are shown in Table 3.

The analysis showed no significant difference (p = 0.170) between the groups in the treatment results.

Characterization of the results of treatment of combined HV of 2nd degree HV type showed a significant (p = 0.001) predominance of better results in the main group: good — 127 (51.6 %) and satisfactory — 102 (41.5 %), in contrast to the number of good results in the control group: good — 21 (23,9 %) and satisfactory — 31 (39.8 %). At the same time, unsati-

sfactory results in the control group were observed almost 6 times more often than in the main group — 36 (40.9%) and 17 (6.9%), respectively.

No significant differences in the treatment results were observed during the treatment of patients with isolated HV with minor degrees of deformation of the 1st degree HV. Therefore, the use of various surgical techniques with minor HV led to good treatment results. As for the 2nd and 3rd degree HV, there were no unsatisfactory results, but the number of good ones in the main group prevailed. First of all, this is due to the fact that the main group used an individual approach to the choice of surgical technique. Regarding the group of patients with the presence of HV, which arose due to the instability of the metatarsal-sphenoid joint, the control group had unsatisfactory results due to the lack of influence on the etiopathogenesis of these deformations, that is, ignoring the sign of instability of this joint, which led to the development of this distortion.

In the group of patients with combined FD (combination of HV and deformations of the 2nd–5th toes) with minor HV distortions and stable metatarsophalangeal joints, there were no unsatisfactory results. Under conditions of curvature of the 2nd–5th toes combined with instability of the metatarsal-phalangeal joints, as well as metatarsalgia, the unsatisfactory results of treatment in the control group significantly exceeded those in the main group. This was due to the presence of recurrence of metatarsalgia in the postoperative period, because no corrective distal metatarsal osteotomies were performed in the control group to elevate their heads to reduce the load on them during walking.

So, if we affect all the chains of the static FD, then the chance of obtaining good and satisfactory results of surgical treatment of these deformities is much higher than in the case of using a mechanistic no-differential approach.

The evaluation of the obtained results was carried out based on the use of the AOFAS score scale, which is generally accepted in the world and is the most widespread. However, like all other scales, it has shortcomings, because it reflects the scientific picture studied by the researcher and does not take into account the subjective data of the patient. Therefore,

Table 3

Combined deformity of valgus deformity of the 1st toe

Group	Result		
	good	satisfactory	незадовільний
1st degree *Hallux valgus*.			
Total (n = 6)	4 (66.7 %)	2 (33.3 %)	—
Control (n = 7)	2 (28.6 %)	5 (71.4 %)	—
In total (n = 13)	6 (46.2 %)	7 (53.8 %)	—
Statistical significance of the difference	V_{kr} = 1.887; p = 0.170 *		
2nd degree *Hallux valgus*.			
Total (n = 246)	127 (51.6 %)	102 (41.5 %)	17 (6.9 %)
Control (n = 88)	21 (23.9 %)	31 (35.2 %)	36 (40.9 %)
In total (n = 334)	148 (44.3 %)	133 (39.8 %)	53 (15.9 %)
Statistical significance of the difference	χ^2 = 59.120; p = 0.001		
3rd degree *Hallux valgus*.			
Total (n = 290)	146 (50.3 %)	122 (42.1 %)	22 (7.6 %)
Control (n = 90)	16 (17.8 %)	29 (32.2 %)	45 (50.0 %)
In total (n = 380)	162 (42.6 %)	151 (39.7 %)	67 (17.6 %)
Statistical significance of the difference	χ^2 = 88.841; p = 0.001		
Hallux valgus due to instability of the metatarsal-sphenoid joint			
Total (n = 8)	5 (62.5 %)	3 (37.5%)	—
Control (n = 3)	—	—	3 (100.0 %)
In total (n = 21)	5 (45.5 %)	3 (27.3 %)	3 (27.3 %)
Statistical significance of the difference	V_{kr} = 1.000; p = 0.004		

Notes: — in 100.0 % the expected frequency was less than 5, Kramer V criterion was used;*
*** — in 6 (100 %) the expected frequency was less than 5, Kramer V criterion was used.*

Table 4

Results of surgical treatment of patients with combined HV of the 2nd–5th toes

Group	Result		
	good	satisfactory	unsatisfactory
Total (n = 550)	282 (51.3 %)	229 (41.6 %)	39 (7.1 %)
Control (n = 188)	39 (20.7 %)	65 (34.6 %)	84 (44.7 %)
Statistical significance of the difference	$\chi^2 = 150.558$; $p < 0.001$		

Table 5

Generalization of the results of treatment of HV in the main and control groups of patients

Group	Result		
	good	satisfactory	unsatisfactory
Total (n = 694)	382 (55.0 %)	272 (39.2 %)	40 (5.8 %)
Control (n = 280)	73 (26.1 %)	121 (43.2 %)	86 (30.7 %)
Statistical significance of the difference	$\chi^2 = 132.655$; $p < 0.001$		

Table 6

The risk of an unsatisfactory result during surgical treatment

Group	Result		Абсолютний ризик незадовільного результату (R)
	unsatisfactory	без ускладнень	
with isolated HV			
Total (n = 142)	1	141	0.007
Control (n = 91)	2	89	0.022
Relative risk (RR ± SE)			0.320 ± 1.217
95 % confidence interval (95 % CI)			[0.029; 3.483]
with combined HV and deformities of the 2nd–5th toes			
Total (n = 142)	39	511	0.071
Control (n = 91)	84	104	0.447
Relative risk (RR ± SE)			0.159 ± 0.174
95 % confidence interval (95 % CI)			[0.113; 0.223]

it is advisable to use several scales that would consider both subjective and objective results to evaluate the consequences of the treatment of patients with static FD.

Conclusions

The obtained results of treatment of patients with static FD according to the summarized data in the main group were statistically significantly ($p < 0.001$) better than the results in the control group of patients. Thus, in the main group, good results were obtained in 55.0 % of cases, satisfactory in 39.2 %, unsatisfactory in 5.8 %. Compared to the control group, good results were obtained in 26.1 %, satisfactory in 43.2 %, and unsatisfactory in 30.7 %, respectively. The number of unsatisfactory results in the control group is primarily related to a standardized, rather than a differential, approach to the treatment of patients with static FD.

In the control group, the risk of an unsatisfactory outcome of isolated HV treatment is three times higher than in the main group. Reduction of the relative risk of obtaining an unsatisfactory result (RRR) in the main group using the proposed algorithmic system of surgical treatment of static FD was 68 %.

In the case of treatment of combined HV with curvatures of the 2nd–5th toes, the risk of an unsatisfactory result was higher compared to isolated HV in both groups.

Unsatisfactory treatment outcome in patients with combined HV deformity and curvatures of the 2nd–5th toes in the control group was 15.9 % higher (RR = 0.159 ± 0.174) than in the main group.

The use of the proposed approach to the selection of treatment tactics based on the developed algorithmic system of surgical treatment of static FD can reduce the relative risk of obtaining unsatisfactory results by 84 % (RRR = 0.841).

In further studies on the evaluation of the results of treatment of patients with static FD, it is advisable to use several evaluation scales in parallel, which will provide an opportunity to comprehensively (objectively and subjectively) determine the results of surgical treatment of patients, which will further contribute to improving the solution of this complex issue.

Conflict of interest. The author declare no conflict of interest.

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DETERMINATION OF THE RISK OF OBTAINING UNSATISFACTORY RESULTS OF SURGICAL TREATMENT OF PATIENTS WITH STATIC DEFORMITIES OF THE FOREFOOT WHEN USING VARIOUS SURGICAL APPROACHES

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