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Syme's operation in the treatment of gunshot injuries of the foot

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Syme's operation for gunshot injuries of the foot may be a viable alternative to transtibial amputation. Objective. To analyze the results of the use of Syme's operation in patients with gunshot injuries of the foot, to highlight the important points of surgical technique, rehabilitation and prosthetics. Methods. The results of treatment of 12 men with gunshot wounds to the foot aged 23–54 years (mean age (36.1 ± 2.7) years) who underwent Syme surgery were analyzed. All patients were military personnel at the time of injury. Clinical, instrumental and microbiological examinations were used. The severity of the injury and the prospects of reconstructive treatment were assessed by the Hannover Fracture Score (HFS-97), the anatomic defect present and the severity of static-dynamic disorders. The results were evaluated according to VAS (pain) and ALAC (prosthesis using). Results. Healing of postoperative wounds in all cases occurred without complications. The observation period was from 8 months. up to 7 years (3.5 years on average). All 10 prosthetic patients use a prosthesis: 1 — walking on a prosthesis outside the home (ALAC IV), 5 — independent mobility (ALAC V), 4 — mobility does not differ from the norm (ALAC VI). In two cases (15,4 %) due to pain syndrome (7,3 and 6,8 according to VAS) prosthetics was impossible — reamputation at the level of the leg. Conclusions. Syme's operation provides a good functional result of prosthetics in case of gunshot injuries of the foot, is a real alternative to transtibial amputation in cases with preserved hindfoot.

Операція Сайма при вогнепальних ушкодженнях стопи може бути реальною альтернативою транстібіальної ампутації. Мета. Проаналізувати результати застосування операції Сайма в пацієнтів із вогнепальними ушкодженнями стопи, висвітлити важливі моменти хірургічної техніки, реабілітації та протезування. Методи. Проаналізовано результати лікування 12 чоловіків із вогнепальними ушкодженнями стопи у віці 23–54 роки (середній вік $(36,1 \pm 2,7)$ року), яким виконали операцію Сайма, усі пацієнти на момент поранення були військовослужбовцями. Застосовувалися клінічні, інструментальні та мікробіологічні обстеження. Тяжкість ушкодження і перспективи реконструктивного лікування оцінювали за Hannover Fracture Score (HFS-97), наявним анатомічним дефектом, вираженістю статико-динамічних розладів. Оцінювання результатів проводили за ВАШ (біль) та шкалою ALAC (користування протезом). Результати. Загоєння післяопераційних ран в усіх випадках сталося без ускладнень. Термін спостереження становив від 8 міс. до 7 років (у середньому 3,5 року). Усі протезовані 10 пацієнтів користуються протезом: 1 — ходьба на протезі за межами помешкання (ALAC IV), 5 — незалежна мобільність (ALAC V), 4 — мобільність не відрізняється від норми (ALAC VI). У двох випадках (15,4 %) через больовий синдром (7,3 та 6,8 за ВАШ) протезування було неможливе — реампуація на рівні гомілки. Висновки. Операція Сайма забезпечує гарний функціональний результат протезування при вогнепальних ушкодженнях стопи, є реальною альтернативою транстібіальної ампутації у випадках збереженого заднього відділу. Ключові слова. Стопа, вогнепальна травма, операція Сайма.

Key words. Foot, gunshot injury, Syme's operation

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Introduction

Treatment of gunshot injuries to the limbs is an urgent problem of modern traumatology due to armed conflicts in various countries of the world. For Ukraine, this problem has gained special importance since 2014, when Russia began armed aggression. Fire injury of the foot is characterized by the complexity of restoring the structures of this part of the human body and requires the involvement of specialists from many surgical specialties. Published results of restorative treatment of gunshot wounds in this area are quite ambiguous due to the heterogeneity of clinical material, different socio-economic conditions of industrialized countries and those that are developing.

The question of amputation of the foot in case of gunshot injuries arises both at the stages of evacuation and in the remote period. In a number of cases, the preservation of the plantar skin of the heel area provides the necessary conditions for the Syme operation, the functional consequences of which, under the conditions of compliance with indications, surgical technique and rehabilitation, exceed the results of transtibial amputation. In the available modern literature, there are few reports on the Syme operation for gunshot wounds of the foot [1, 2], although the functional capabilities of the residual limb after exarticulation in the supracalcaneal joint provide not only full-fledged independent locomotion, but also the possibility of short-term loading without a prosthesis.

We hope that our modest experience of using the Syme operation in the case of gunshot wounds to the foot will contribute to the return of this undeservedly forgotten operation to wider use in Ukraine.

Purpose: to analyze the results of the use of Syme operation in patients with gunshot injuries of the foot, to highlight the important points of surgical technique, rehabilitation and prosthetics.

Material and methods

The study involves (since 2016) 12 male patients with gunshot wounds to the foot who underwent Syme surgery. Their age was 23–54 years (on aver-

age (36.1 ± 2.7) years), all patients were servicemen of Ukraine at the time of injury. The study was approved by the academic council of the State Establishment “Institute of Traumatology and Orthopedics of the National Academy of Sciences of Ukraine” (Protocol No. 8 dated 18 April 2023), its conduct was in accordance with the principles of the Helsinki Declaration on Human Rights and the requirements of the local bioethics committee. Informed consent was obtained from all patients. Study design: case series, retrospective analysis.

The study implied assessment of the clinical material, the nature of the injury (explosive mine injury (EMI), shrapnel, bullet), single or multiple injury, time since the injury, the number of surgical treatments and, separately, the number of interventions before the Syme operation (re-amputation, osteosynthesis, cement-antibiotic spacer implantation, autodermoplasty, skin plastic with a rotary or microvascular flap). Patient data are shown in Table 1.

Examination of patients

Clinical: sensitivity of the plantar surface of the foot, compensation of regional blood flow (pulsation of *aa. tibialis posterior, dorsalis pedis*); the volume of active and passive movements in the supracalcaneal-tibia joint.

Instrumental: ultrasound flowmetry or dopplerography in the case of impossibility of clinical observation of pulsation during the study of blood flow along *a. tibialis posterior*, X-ray, CT and MRI as indicated.

Microbiological: in the presence of an infectious process, during surgery - biopsy material, in the case of open wound surfaces or in suspicious cases. Evaluation of fresh injuries was carried out according to HFS-97 [3], under the conditions of the consequences, the existing anatomical defect, the severity of static-dynamic disorders and the prospects of further restorative treatment were studied.

Indications for Syme surgery: severe foot injury precluding successful anterior amputation/re-amputation, HFS97 total score > 20.

Table 1

Characteristics of clinical material

Injury nature	Mono/Polytrauma	Number of surgical treatments on the foot	Number of interventions on the foot	Time since injury
EMI: – anti-personnel mine; – explosion in the car	4/2 0/1	2–8 (4.3 on average) 4	1–4 (3.0 on average) 3	from 3 days to 8 months (3 months and 12 days on average)
Shrapnel	2/2	2–4 (3.0 on average)	1–5 (3.4 on average)	
Bullet	1/0	3	—	

Contraindications: lack of blood flow along a. tibi-
alis posterior, the patient's desire to keep the residual
foot.

Preparation for surgery

In cases of fresh injuries, staged amputation was performed at the level of the transverse metatarsal joint in order to rehabilitate the residual limb as quickly as possible. Based on the condition of the tissues, a decision was made to manage the wound — open or with the use of negative controlled pressure. Prevention of thromboembolism and antibacterial therapy were carried out in accordance with current hospital instructions.

Operation technique

Position of the patient on the back, tourniquet on the thigh. Access: Anterior transverse component — 1 cm distal and 1 cm anterior to the bimalleolar line, both ends of this incision were joined by a stirrup incision anterior to the heel fat pad. Cutaneous nerves (*nn. suralis, peroneus profundus*) were carefully selected and crossed, taking care not to get them into the scar. The capsule of the metatarsal joint was dissected, the foot was bent, and a single-toothed hook was inserted into the metatarsal bone. Traction by the hook allowed us to visualize the tendon of *m. flexor hallucis longus*, medial to which is the tibial vascular-nerve bundle. The lateral ligaments were carefully crossed, the calcaneus was freed from the tissues, while avoiding strong stretching of the tissues. A single-toothed hook was placed on the back surface of the calcaneus, pulled downwards, and the Achilles tendon and plantar tissues were cut off. Excision of the foot was completed by crossing the aponeurosis. The tourniquet was released and the blood flow through the flap was assessed. If there was no bleeding from the edges of the flap, despite the indicators of preoperative studies, a decision was made on transtibial amputation (TTA).

In case of bleeding from the edges of the flap, the operation was continued. Approximately 1.0–1.5 cm of the epiphysis of the *tibia* together with the bones were cut off, the dissection plane should be perpendicular to the axis of the *tibia*. All the tendons that appeared in the wound were crossed as proximally as possible. The “ceiling” in the bone area was a little narrowed. Before suturing, the skin flaps were adapted and, if there was excess tissue, the dorsal flap was shortened. Tubular drainage was installed, the plantar cushion was centered on the surface of the *tibia*, and the skin was sutured. It is important to adequately drain the large dead space after metatarsal and calcaneus extraction. To reduce the dead space, a plantar flap was sewn

with a through seam, which was brought to the skin of the front surface of the lower leg.

In the absence of indications, the first dressing was performed after 48 hours, then the drain was removed. Three weeks after the operation, the sutures were removed and a circular plaster cast with a ring was applied, in which full weight bearing was started. Plaster was changed as the stump lost weight until its volume stabilized. During the manufacture of the prosthesis, the patients walked in a plaster cast.

The results were evaluated according to the following indicators: healing of the postoperative wound, pain in the residual limb (severity according to VAS), the need for re-amputation, the level of prosthesis use according to the ALAC (Artificial Limb and Appliance Center) scale [4]:

- I. The prosthesis has exclusively cosmetic significance;
- II. The prosthesis is used only for transportation;
- III. Walking on a prosthesis inside the house;
- IV. Walking on a prosthesis outside the home;
- V. Independent mobility of the prosthetic device;
- VI. The mobility of the prosthetic device does not differ from the norm.

Items III and IV include the use of crutches, crutches, or walkers.

Results

Healing of postoperative wounds in all cases occurred without complications. The observation period was from 8 months up to 7 years (3.5 years on average). In two patients, a violation of the postoperative rehabilitation protocol resulted in chronic pain in the residual limb, which ultimately led to re-amputation at the lower leg. In all other cases, the patients were successfully implanted: 5 of them had independent mobility (ALAC V), in 4 the mobility did not differ from the norm (ALAC VI) (Figure). The functional results of the treatment are shown in Table 2.

As can be seen from the Table, all 10 prosthetic patients used the prosthesis, and 9 of them had mobility levels V and VI on the ALAC scale. Five of them returned to military service, 5 of those who were discharged have permanent employment.

Discussion

J. Syme in 1842 published the technique and results of exarticulation in the supracalcaneal-tibial joint using the plantar skin of the heel area to close the tibial fissure [5]. The operation turned out to be extremely effective in the case of amputation of the foot due to various disorders of acquired and congenital origin, and the idea gave birth to a number

Table 2

Functional results of Syme operation

Result of treatment	VAS (pain, cm)	Returned to military service	Discharged, but working	Discharged, not working
ALAC IV (n = 1)	2.0 (1.2 – 2.9)	—	1	—
ALAC V (n = 5)	1.8 (0.7 – 2.3)	2	2	1
ALAC VI (n = 4)	0.9 (0.4 – 1.5)	3	1	—
pe-TTA (n = 2)	7.3; 6.8	—	1	1



Figure. Explosive-mine injury of the right foot (anti-personnel mine) of 2 weeks standing. View (a) and X-ray (b) of the injured foot before Syme operation. X-ray (c) and view (d) of the residual limb 6 months after surgery. Functional result of prosthetic care (e)

of osteoplastic modifications: operations by M. I. Pirogov, H. B. Boyd, G. Neff, and others. The advantages of the Syme operation are low energy consumption during walking, durable and load-bearing residual limb, preservation of proprioception [1, 6]. Disadvantages include migration of the plantar flap, non-cosmetic appearance, and a significant proportion of re-amputations in adult patients [1, 2].

Syme operation has found wide use in diabetic foot surgery, however, in the case of traumatic cases, it is used much less. Thus, in a systematic review of the literature by R. Braaksma et al. [2], among the selected 36 full-text publications on Syme operation, only 3 are devoted to traumatic cases in adults. The patient population was 1,056, of which 213 were traumatic cases.

When considering combat trauma, information on Syme surgery for gunshot wounds to the lower

extremity is patchy and scarce. F. A. Rathore et al. [7] reported 9 cases in Pakistani army servicemen during the period 2007–2011, which accounted for 7.3% of all lower extremity amputations. According to the data of C. A. Krueger et al. [8], the percentage of exarticulations at the level of the supracalcaneal-tibia joint among all amputations in American soldiers injured during the stay of the joint contingent in Iraq and Afghanistan (2001–2011) was 1.5 % (25 cases). In Asian countries, the Syme operation is practiced more widely. Thus, S. Necmioglu et al. (Turkey) [9] published the results of treatment of 186 cases (1993–2001) of lower extremity injuries due to mine explosions. In their series of observations, the number of exarticulations at the level of the supracalcaneal-tibial joint was 24 cases (23.8 %), and the per-

centage of re-amputations after the Syme operation at the level of the tibia was 4.2 % (1 case).

The effectiveness of the Syme surgery in traumatic cases is highlighted in a systematic review by R. Braaksma et al. [2]. Problems with wound healing were noted in 5 %, re-amputations at the level of the leg in 23 %. Our patients had no problems with the healing of the postoperative wound, re-amputation at the level of the lower leg was performed in 2 cases (15.4 %). In these cases, non-compliance with the postoperative rehabilitation protocol (lack of adaptation of the residual limb to full load in a plaster cast) caused a pronounced pain syndrome during the use of the prosthesis, which became a strong indication for re-amputation at the level of the lower leg.

According to the data of R. Braaksma et al. [2], the percentage of prosthesis use was 78 %, and 66 % of prosthetic patients had permanent employment. Due to the lack of relevant information in the sources selected for systematic analysis, the functional capacity of prosthetic persons was not analyzed. Among our patients, out of 11 subjects with prostheses, 10 had mobility levels V and VI, 5 patients returned to military service (50 %). The other 5 were released from military service but have permanent employment.

The advantage of our study is the assessment of functional results of the Syme operation for gunshot injuries of the foot in cases where the preservation of the bearing capacity of the lower limb is impossible or previous reconstructive interventions could not provide it. In such cases, re-amputation at the level of the tibia is formally indicated, with the features, complications and cost of prosthetic repair inherent in transtibial amputation. At the same time, the successful operation of Syme makes independent mobility possible for a lower cost of the prosthesis, and inside the house the patient can walk on the residual limb without it. Even in cases where re-amputation is required, the patient and surgeon have a good reserve of length.

We cannot compare the obtained results with the literature data due to the lack of similar studies, but it should be noted that there are also no comparative studies of the results of the Syme operation and transtibial amputation for gunshot injuries.

Conclusions

Syme's operation provides a good functional result of prosthetic repair for gunshot injuries of the foot, is a real alternative to transtibial amputation in cases of such injuries with a preserved posterior part of the foot. Covering the end of the residual limb with specialized plantar skin creates conditions for almost complete resistance, which significantly speeds up rehabilitation after prosthetic repair. An additional advantage is significantly lower costs for the manufacture of a prosthesis compared to transtibial amputation. Further comparative studies of quality of life and functional capacity of patients undergoing transtibial amputation and Syme's operation will contribute to a differentiated approach to the selection of the level of amputation of the lower extremity for gunshot injuries of the foot and the wider application of Syme's operation.

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

References

- Hudson, J. R., Yu, G. V., Marzano, R., & Vincent, A. L. (2002). Syme's amputation: surgical technique, prosthetic considerations, and case reports. *Journal of American Podiatric Medical Association*. 92 (4), 232–246. <https://doi.org/10.7547/87507315-92-4-232>.
- Braaksma, R., Dijkstra, P. U., & Geertzen, J. H. B. (2018). Syme amputation: a systematic review. *Foot and Ankle International*. 39(3), 284–291. <https://doi.org/10.1177/1071100717745313>.
- Krettek, C., Seekamp, A., Kontopp, H., & Tscherne, H. (2001). Hannover Fracture Scale 98 — reevaluation and new perspectives of an established extremity salvage score. *Injury*. 32(4), 317–328. [https://doi.org/10.1016/s0020-1383\(00\)00201-1](https://doi.org/10.1016/s0020-1383(00)00201-1).
- Campbell, W. B., Johnston, J. A. St., Kernick, V. F. M., & Rutter, E. A. (1994). Lower limb amputation: striking the balance. *Annals of the Royal College of Surgeons of England*. 76(2), 205–209. PMID: 7755684.
- Syme, J. (1824). Remarks on amputation. *Edinburg Medical Surgical Journal*. 21(78), 27–42. PMID: PMC5826404.
- Pinzur, M. S. (1999). Restoration of walking ability with Syme's ankle disarticulation. *Clinical Orthopedics and Related Research*. 361, 71–75. <https://doi.org/10.1097/00003086-199904000-00010>.
- Rathore, F. A., Ayaz, S. B., Mansoor, S. N., Qureshi, A. R., & Fahim, M. (2016). Demographics of lower limb amputations in the Pakistan military: a single center, three-year prospective survey. *Cureus*. 8(4), e566. <https://doi.org/10.7759/cureus.566>.
- Krueger, C. A., Wenke, J. C., & Ficke, J. R. (2012). Ten years at war: comprehensive analysis of amputation trends. *Journal of Trauma and Acute Care Surgery*. 73(6 Suppl 5), S438–444. <https://doi.org/10.1097/TA.0b013e318275469c>.
- Necmioglu, S., Subasi, M., Kayikci, C., Young, D. B. (2004). Lower limb landmine injuries. *Prosthetics and Orthotics International*. 28(1), 37–43. <https://doi.org/10.3109/03093640409167923>

SYME'S OPERATION IN THE TREATMENT OF GUNSHOT INJURIES OF THE FOOT

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