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Replacement of Calcaneal Defects due to Mine-Blast Injury with Femoral Head Allograft. Case Studies and Brief Review of the Literature

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Summary. *Two cases of post-traumatic defects of the calcaneus resulting from mine-blast injury (stepping on a mine) are presented. After appropriate sequential treatment, the calcaneal defects were replaced with an allogeneic femoral head. The follow-up periods were 20 and 6 months, respectively. A review of the literature is presented.*

Key words: *os calcaneus; mine-blast injury; alloplasty.*

Tissue defects in the heel area is a difficult problem at all stages of treatment. Involvement of this part of human body in armed conflicts tends to increase and is accompanied by a significant proportions of amputations above the ankle joint [1, 2]. An important issue that arises with sufficient preservation of the skin, and especially the skin of the supporting surface of the heel area, is the replacement of a total or subtotal defect of the calcaneus. Surgical solutions are represented by Ilizarov bone transport, osteocutaneous microvascular flap transplantation, and bone defect replacement with an allograft from the femoral head [3–5].

We present two cases of replacement of a calcaneal defect due to a mine-blast injury using an allogeneic femoral head. Written informed consent for the publication of photographic materials was obtained from the patients. Ethical standards comply with the principles of Helsinki Declaration of Human Rights and the requirements of the local bioethics committee.

Case 1. A 52-year-old man, a serviceman of the Armed Forces of Ukraine, sustained a mine-explosive wound to his left foot from the explosion of a «petal» type anti-personnel mine. He was equipped with high-protection footwear. An open multi-fragmental fracture of the right calcaneus occurred. Treatment during evacuation consisted of surgical debridements, removal of non-viable fragments, antibacterial therapy, and several NPWT sessions. Wound healing was achieved 3 months after the injury. Attempts to provide individual orthotic support with an insole to compensate for the height defect of the hindfoot were unsuccessful.

The patient's condition at the time of admission (6 months after injury) was as follows: partial load on the forefoot was possible, a loose longitudinal scar was present on the supporting surface of the heel area, and sensitivity was fully preserved. Sufficient skin margin was noted during palpation. A subtotal defect of the calcaneus was observed on the lateral X-ray (Fig. 1).

The patient was operated on under spinal anesthesia in the prone position. Preparation of the recipient bed involved refreshing of the anterior process and a small fragment of the lateral part of the calcaneus, as well as resection of the posterior articular surface of the talus. The samples of bone and scar tissues from the surgical site were taken for bacteriological examination. A fragment of an allogeneic femoral head of the appropriate shape was tightly inserted into the prepared bed. Fixation was performed with a 7.3 mm cannulated screw inserted through the graft into the neck of the talus. With another 4.0 mm cannulated screw, the graft was fixed to the small fragment of calcaneus remaining on the lateral side. Finally, a small fragment with the Achilles tendon attachment site was fixed to the graft with a 4.0 mm screw (Fig. 2). The postoperative period passed without complications. Antibacterial prophylaxis with Kimacef (due to hypersensitivity to ceftriaxone) was administered for 3 days, until a negative result of bacterial culture was confirmed. The limb was immobilized with a removable plaster cast for 4 weeks. The patient began full weight-bearing in a modeled plaster cast with a walking platform 8 weeks after the surgery.

At the 6-months follow-up, the patient walked without additional support and showed no signs of limping. Shortly after the examination, the exostosis of the plantar surface of the foot was resected, two screws were removed, and the protruding bone edge at the attachment site of the Achilles tendon was

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Fig.1. Case 1. Plantar surface and weight-bearing X-ray of the left foot.

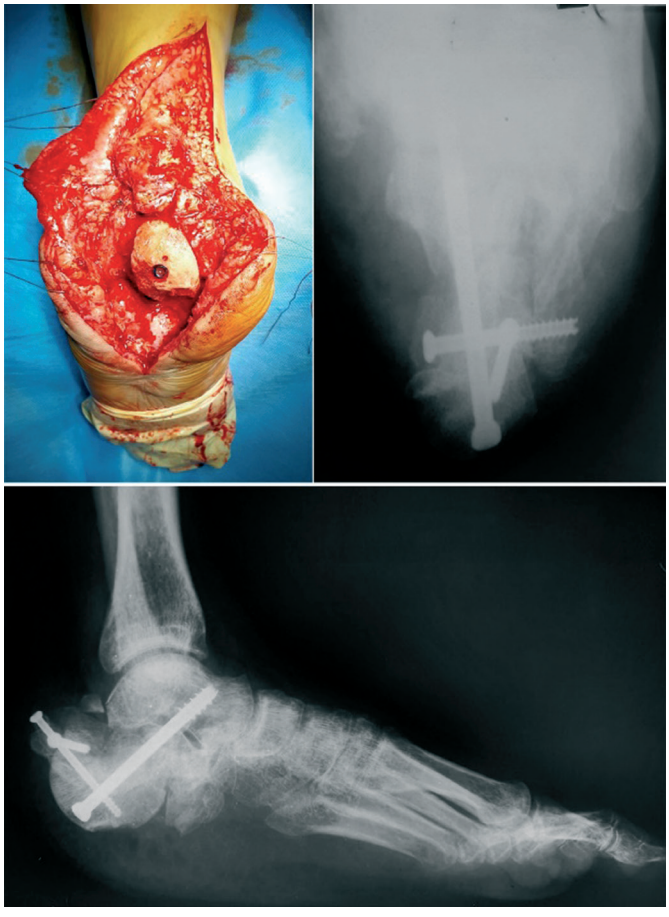

Fig. 2. Case 1. View of the surgical field and X-ray of the foot after surgery.

Fig. 3. Case 1. Twenty months after surgery. General appearance and radiographs of the foot. Patient's functional capabilities.

resected. At the final follow-up of 18 months from the femoral head transplantation, the patient was able to full weight-bearing without any devices and reported no pain (Fig. 3). Radiographs showed bone fusion between transplanted femoral head and host bed.

Case 2. A 43-year-old man, a police officer, sustained a mine-explosive wound to his right foot, perineum, buttocks and thighs from an improvised explosive device. The wound of his right foot was presented by the open comminuted fracture of the calcaneus (Gustilo-Anderson IIIB). On the same day, wound debridement and immobilization of the fracture with a foot-leg external fixation apparatus were performed. Further treatment included necrectomy and 6 sessions of NPWT.

The patient was admitted 6 weeks after injury with an external fixator on his right leg and foot. A wound on the medial surface of the calcaneal region measuring 5x5x2.5 cm was covered with a silver aseptic bandage. Radiographs displayed comminuted fracture of the calcaneus with bone defect. Movements in the toe joints were preserved; no neurological and vascular disorders were observed (Fig. 4).

One week after the removal of the external fixator, the first stage of reconstruction was performed. The wound was carefully debrided, and the bone defect was filled with a polymethylmetacrylate-antibiotic spacer shaped like a ball. The spacer was fixed to the talus with a wire. The soft-tissue and skin defect was replaced with a 7x5 cm sural flap (Fig. 5). Antibiotic prophylaxis was initiated with ceftriaxone. Bacterial culture from the biopsy specimen revealed Ps. aeruginosa 106, and meropenem was administered for 14 days. After the wounds healed, the patient maintained range of motion in the ankle joint and toes.

Three months later, the spacer was removed and the femoral head allograft was used for replacement of the calcaneus. Meropenem was initiated on the day of surgery and continued for 10 days after receiving culture results. Access was achieved through the postoperative scar between the plantar skin and the sural flap. After removing the spacer, a well-defined membrane was seen. A proximal dome of the membrane was incised and a bone bed was prepared

Fig. 4. Case 2. Patient's right foot and X-ray of the foot at the time of admission.

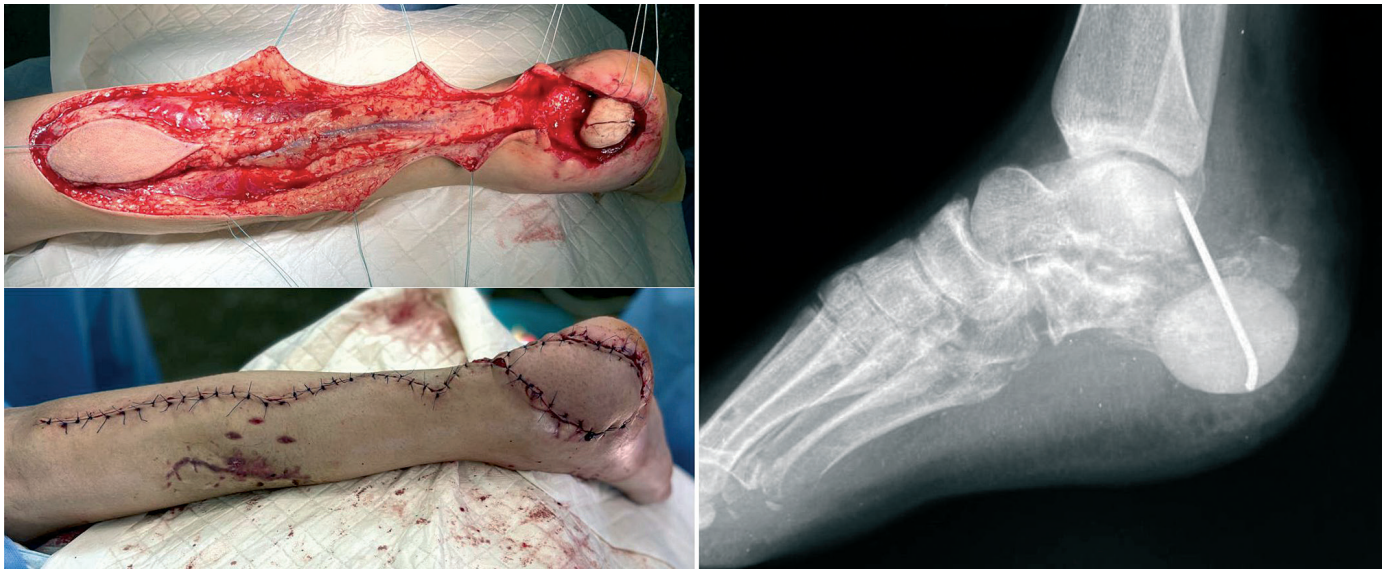

Fig. 5. Case 2. The first stage of the reconstruction: insertion of PMMC-antibiotic spacer and distal-pedicled sural flap transposition.

through this opening. Two tissue samples were taken for bacterial culture: the first was a membrane fragment (no growth), and the second was a bone fragment from the bed (growth of Ps. aeruginosa 103 on the third day after the surgery). A femoral head fragment of appropriate size was tightly aligned with the bone bed and fixed to the talus with a 7.3 mm cannulated screw.

No complications were observed during the follow-up period. Bone union between the graft and the bones of the recipient bed was radiographically observed 2 months after surgery. The patient began to load the leg in the orthosis, and full load was allowed after another month.

At a control examination 6 months after surgery, the patient used his right leg without restrictions. Radiographic evaluation showed consolidation and no signs of graft resorption (Fig. 6). Range of motion in the ankle joint S was as follows: 10-0-150/15-0-250.

Discussion

Post-traumatic defects of the calcaneus are a complex and unsolved problem in reconstructive orthopedics. The absence of the calcaneus significantly disrupts the supporting function of the foot due to a specific rigid deformation and a significant reduction in the range of motion in the ankle joint. Gunshot fractures of the calcaneus, as a type of the most severe open injuries of the hindfoot, are characterized by multifragmentation, skin defects, and the presence of aggressive cultures.

Treatment can be quite lengthy and in most cases is unpredictable, even when microsurgery is used. A common solution for patients with calcaneal gunshot wounds and their sequelae is transtibial amputation.

The central point of this problem is the restoration of the calcaneus as a supporting structure by replacing it. Variants of plastic replacement of

Fig. 6. Case 2. Six months after surgery. Functional and radiographic results.

calcaneal defects presented in the literature include bone transport of an osteotomized fragment of the tibial epiphysis, transplantation of a complex free microsurgical fibular graft, auto- and alloplasty, and synthetic implants [3–7].

Alloplasty using the femoral head appears to be the most logical solution, as it allows restoration of the characteristic shape of the supporting part of the calcaneus. A similar approach has been used by some authors [5–7]. Regarding calcaneal defects after gunshot injury, we were able to find only one clinical case [5]. The authors replaced the defect in the heel tissue in two stages. First, a skin reserve was provided using an expander, after which an allograft of appropriate size was implanted. Demineralized bone matrix, bone morphogenic protein, and concentrated bone marrow aspirate were used to improve graft remodeling. The long-term result was recorded after 17 months and was presented by a lateral load X-ray picture.

We have successfully used an allogeneic femoral head in two cases of calcaneal gunshot defects. This decision was based on the presence of intact skin on the supporting surface of the heel area and the preservation of sufficient active function of the ankle joint and the distal part of the foot.

In our opinion, the possibility of plastic replacement of the defect in the calcaneal tissue in the aspect of future reconstruction of the calcaneus should be considered if the forefoot is anatomically and functionally preserved. This is a guarantee of sufficient compensation for the injured foot after the completion of treatment.

Another important factor to consider is the availability of sufficient skin, particularly the specialized skin of the bearing heel surface, which will allow for full weight-bearing of the reconstructed calcaneus.

It should be noted that the presented cases, as well as similar ones, are uncommon. We want to warn colleagues against excessive enthusiasm, because in our daily practice, we quite often prefer transtibial amputation for gunshot wounds of the hindfoot and their consequences.

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Заміщення дефектів п'яткової кістки внаслідок мінно-вибухової травми аллогенною головкою стегнової кістки. Клінічні випадки та короткий огляд літератури

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Резюме. *Представлені два випадки посттравматичних дефектів п'яткової кістки, що виникли внаслідок мінно-вибухової травми (наступання на міну). Після відповідного послідовного лікування дефекти п'яткової кістки були заміщені аллогенною головкою стегнової кістки. Терміни спостереження становили 20 та 6 місяців відповідно. Представлено огляд літератури.*

Ключові слова: *п'яткова кістка, мінно-вибухова травма, аллопластика.*