

LEČENJE KOMPLEKSNE POVREDE STOPALA UPOTREBOM VACUUM ASSISTED CLOSURE I PLATELET-RICH FIBRIN METODE – PRIKAZ SLUČAJA

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CASE REPORT

COMPLEX FOOT INJURY TREATMENT USING VACUUM ASSISTED CLOSURE AND PLATELET-RICH FIBRIN METHOD – CASE REPORT

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SAŽETAK

Uvod: Saobraćajni traumatizam predstavlja jedan od vodećih uzroka smrti i povreda širom sveta. Prema podacima Svetske zdravstvene organizacije (SZO), više od 1,3 miliona ljudi godišnje izgubi život u saobraćajnim nesrećama, dok je između 20 i 50 miliona osoba povređeno. Veći deo povreda izazvanih saobraćajnim nesrećama obuhvata traume ekstremiteta, pri čemu su donji ekstremiteti najčešće povređeni kod pešaka i motociklista.

Prikaz slučaja: Prikazujemo slučaj pacijentkinje stare 77 godina koja je pretrpela saobraćajnu nezgodu kao pešak, zadobivši otvorene prelome II i III metatarsalne kosti leve noge (Gustillo tip II). Inicijalno je primenjeno hirurško lečenje odmah nakon povrede, koje je uključivalo obilnu lavažu, debridman i stabilizaciju preloma K-iglama, uz potkolenu gipsanu imobilizaciju i trojnu antibiotsku terapiju. Dalje, kompleksno lečenje je zahtevalo kombinovano lečenje metodom vacuum-assisted closure (V.A.C.) i platelet-rich fibrin (PRF) i tretmanima u hiperbaričnoj komori (HBO).

Zaključak: Pravovremeno operativno lečenje bilo je ključno za postizanje pozitivnog ishoda kod pacijentkinje starije životne dobi, čime je omogućeno zarastanje bez infekcija i funkcionalan oporavak. Multidisciplinarni pristup pokazao se neophodnim u ovom složenom slučaju, prilagođavajući terapiju specifičnim potrebama starijeg pacijenta i poboljšavajući sveobuhvatni oporavak.

Ključne reči: otvoreni prelom, defekt kože, hiperbarična komora

ABSTRACT

Introduction: Traffic accidents are one of the leading causes of death and injuries worldwide. According to the World Health Organization (WHO), more than 1.3 million people die annually in road accidents, while between 20 and 50 million suffer injuries. The majority of these injuries involve limb trauma, with the lower limbs being most commonly affected, particularly among pedestrians and motorcyclists.

Case report: This report presents the case of a 77-year-old female pedestrian involved in a road accident, sustaining open fractures of the second and third metatarsal bones of the left foot (Gustilo type II). Initial surgical treatment was performed immediately after the injury, including extensive irrigation, debridement, and fracture stabilization using K-wires, along with below-knee plaster immobilization and triple antibiotic therapy. Further complex treatment involved a combination of vacuum-assisted closure (V.A.C.), platelet-rich fibrin (PRF) application, and hyperbaric oxygen therapy (HBO).

Conclusion: Timely surgical intervention was crucial for achieving a positive outcome in an elderly patient, ensuring healing without infection and functional recovery. A multidisciplinary approach was essential in this complex case, adapting therapy to the specific needs of an elderly patient and improving overall recovery.

Keywords: open fracture, skin defect, hyperbaric oxygen therapy

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UVOD

Saobraćajni traumatizam predstavlja jedan od vodećih uzroka smrti i povreda širom sveta. Prema podacima Svetske zdravstvene organizacije (SZO), više od 1,3 miliona ljudi godišnje izgubi život u saobraćajnim nesrećama, dok je između 20 i 50 miliona osoba povređeno. Osmi je vodeći uzrok smrti za sve starosne grupe, nadmašujući HIV/AIDS, tuberkulozu i dijareju [1]. Veći deo povreda izazvanih saobraćajnim nesrećama obuhvata traume ekstremiteta, pri čemu su donji ekstremiteti najčešće povređeni kod pešaka i motociklista, koji su posebno eksponirani zbog odsustva zaštitnih struktura koje su prisutne kod vozača u vozilima [2].

Prema podacima Nacionalne uprave za bezbednost saobraćaja na putevima (NHTSA – National Highway Traffic Safety Administration), pešaci čine između 16 i 17% svih smrtnih slučajeva u saobraćaju u Sjedinjenim Američkim Državama, u petogodišnjem periodu praćenja od 2017. do 2021. godine [3].

Povrede stopala i donjih ekstremiteta prilikom gaženja vozilom spadaju među najozbiljnije povrede koje pešaci mogu zadobiti u odnosu na druge delove tela (Grafikon 1). Podaci pokazuju da je najveći broj povređenih pešaka (42,10%) bio starosne dobi od 41 do 69 godina, a 81,31% činili su muškarci [4]. U ovim slučajevima, terapije kao što su V.A.C. (vacuum-assisted closure) terapija i hiperbarična oksigenacija mogu značajno doprineti bržem oporavku i smanjenju komplikacija [5].

Cilj ovog rada je da prikaže neophodnost multidisciplinarnog u lečenju kompleksnih povreda, kao i da

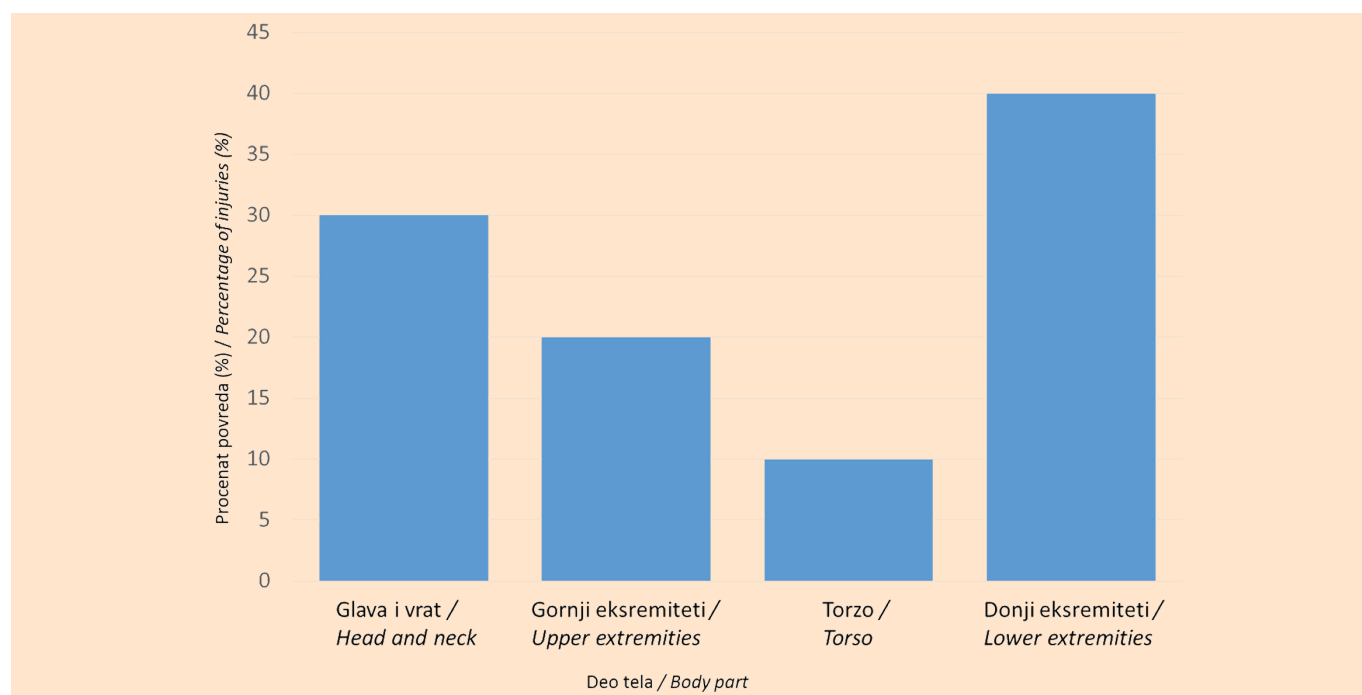
INTRODUCTION

Traffic-related trauma is one of the leading causes of death and injury worldwide. According to the World Health Organization (WHO), more than 1.3 million people die annually in road traffic accidents, while between 20 and 50 million are injured. It is the eighth leading cause of death across all age groups, surpassing HIV/AIDS, tuberculosis, and diarrheal diseases [1]. A large portion of traffic-related injuries involve limb trauma, with the lower extremities most commonly affected, particularly among pedestrians and motorcyclists who are more exposed due to the lack of protective structures present in vehicles [2].

According to data from the National Highway Traffic Safety Administration (NHTSA), pedestrians accounted for between 16% and 17% of all traffic-related fatalities in the United States during the five years from 2017 to 2021 [3].

Foot and lower limb injuries caused by vehicle run-over incidents are among the most severe injuries a pedestrian can sustain (Chart 1). Data shows that the majority of injured pedestrians (42.10%) were aged 41 to 69, and 81.31% were male [4]. In such cases, therapies such as vacuum-assisted closure (V.A.C.) and hyperbaric oxygen therapy (HBOT) can significantly contribute to faster recovery and reduced complications [5].

This case report aims to highlight the necessity of a multidisciplinary approach in treating complex injuries and to emphasize that the timely selection of appropriate therapeutic protocols can result in both functional-



Grafikon 1. Distribucija povreda po delovima tela - World Health Organization (WHO), Global Status Report on Road Safety, 2018

Figure 1. Distribution of body part injuries - World Health Organization (WHO), Global Status Report on Road Safety, 2018

istakne da pravovremeni odabir odgovarajućeg terapijskog protokola daje rezultate koji su i funkcionalno i estetski zadovoljavajući, s obzirom na obim povrede.

PRIKAZ SLUČAJA

Pacijentkinja, starosti 77 godina, povređena je kao pešak kada joj je autobus prešao preko levog stopala. Na pregledu su konstatovani otvoreni prelomi II i III metatarsalne kosti (Gustillo tip II), uz prisutno oštećenja kože i kompresiju tetiva ekstenzorne grupe na dorzalnoj strani stopala, uz uredan neurovaskularni nalaz (Slika 1, Slika 2). Na dan povrede, učinjeno je operativno lečenje koje je uključivalo obilno ispiranje rana, mekotkivni debridman i fiksaciju preloma II i III metatarsalne kosti (MT) Kirschner iglama (K iglama). Postavljena je potkolena gipsana imobilizacija, a ordinirana je trojna antibiotska terapija: Azaran 1 g intravenski, dva puta dnevno; Amikacin 500 mg intravenski, dva puta dnevno i solucija Orvagila, 500 ml intravenski, tri puta 500 ml dnevno. Pacijentkinja je primila antikoagulantnu profilaksu (Fraxiparin u dozi od

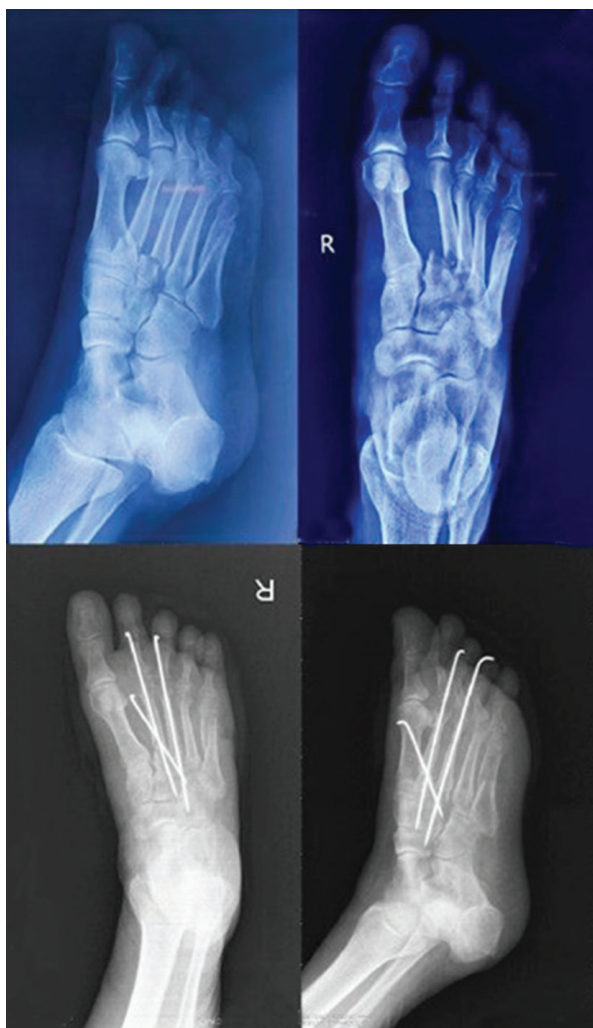
ly and aesthetically satisfactory outcomes, considering the extent of the injury.

CASE REPORT

A 77-year-old female patient was injured as a pedestrian when a bus ran over her left foot. Examination revealed open fractures of the II and III metatarsal bones (Gustilo type II), with skin damage and compression of the extensor tendons on the dorsal aspect of the foot, but with preserved neurovascular status (Figure 1, Figure 2). On the day of injury, surgical treatment was performed, which included extensive wound irrigation, soft tissue debridement, and fixation of the II and III metatarsal bones with Kirschner wires (K-wires). A below-knee plaster cast was applied, and triple antibiotic therapy was administered: Azaran 1 g IV twice daily, Amikacin 500 mg IV twice daily, and Orvagil solution 500 ml IV three times daily. The patient also received anticoagulant prophylaxis (Fraxiparin 0.6 ml subcutaneously once daily) and tetanus prophylaxis (Tetagam 250 IU/ml serum and Tetavaksal 40 IU/0.5 ml vaccine), in accordance with the immunization schedule [6].

Three days post-surgery, the patient began hyperbaric oxygen therapy (HBOT) to achieve hyperoxia and promote soft tissue healing. A total of 20 HBOT sessions were completed. The wounds were regularly dressed and managed with serial debridements. Despite treatment, skin necrosis developed on the dorsal aspect of the foot. Thirty-three days post-injury, a second surgical intervention was performed. This included repeated soft tissue debridement and excision of necrotic tissue from the dorsal foot, resulting in a skin defect that was managed with a V.A.C. device (V.A.C. Ulta®), applied under continuous pressure of 125 mmHg.

On day 36 post-injury, the skin defect was treated with platelet-rich fibrin (PRF), manufactured by Vivostat®. PRF is prepared in a closed system to concentrate fibrin and platelets 7–10 times above normal values from 120 ml of the patient's autologous blood, drawn 15 minutes before anesthesia. The blood is collected directly into specially designed, single-use, sterile bottles. The automated preparation process takes about 25 minutes and yields 5–6 ml of the final product. The automated process is carried out in the anteroom of the operating block, and upon completion of centrifugation, the final product cassette is brought into the operating room and inserted into the Vivostat® applicator, where the solution is buffered. A sterile system is directly connected to the applicator unit, which includes a spray option for solution application. The application process lasts 3–4 minutes. When the spray is applied to the donor site defect, immediate polymerization occurs, re-



Slika 1. Radiografija stopala nakon povrede i nakon operativnog lečenja

Figure 1. Radiography of the foot after injury and after operative



Slika 2. Klinički nalaz povrede

Figure 2. The foot after injury

0,6 ml subkutano, jednom dnevno), kao i antitetanusnu profilaksu (serum Tetagam 250 i.j./ml, i vakcina Tetavak-sal 40 i.j. / 0,5 ml) u skladu sa kalendarom vakcinacije [6].

Tri dana nakon operacije, pacijentkinja je započela terapiju u hiperbaričnoj komori (HBO) kako bi se dobili uslovi hiperoksije koji su doveli do poboljšanja zarastanja mekih tkiva. Ukupno je sprovedeno dvadeset terapija u HBO komori. Rane su redovno previjane i obrađivane u smislu sukcesivnih debridmana. Uprkos primenjenim merama lečenja dolazi do razvoja nekroze kože na dorzalnoj strani stopala. Trideset tri dana nakon povrede je obavljena druga hirurška intervencija. Tokom te procedure izvršen je ponovni debridman mekih tkiva i uklanjanje polja nekroze sa dorzuma stopala nakon čega je zaostao defekt kože, a na koji je postavljen V.A.C. aparat (vakumska terapija negativnim pritiskom za zarastanje rana), proizvođača V.A.C. Ulta[®], pod režimom kontinuiranog pritiska 125 mgHg.

U daljem toku lečenja, 36-og dana nakon povrede, defekt kože je pokriven PRF-om (fibrin bogat trombocitima), proizvođača Vivostat[®]. Priprema Vivostata[®] PRF se vrši u zatvorenom sistemu sa ciljem dobijanja koncentracije fibrina i trombocita 7–10 puta većih od normalnih vrednosti, dobijenih iz 120 ml autologe krvi pacijenta, koja se uzima 15 minuta pre uvođenja u anesteziju. Krv se direktno prikuplja u specijalno dizajnirane, jednokratne sterilne boce. Automatizovani proces pripreme traje do 25 minuta i rezultira sa 5–6 ml finalnog proizvoda. Sam automatizovani proces se vrši u predsali operacionog bloka, a po završetku centrifugiranja se unosi u operacionu salu i kaseta sa dobijenim finalnim proizvodom se aplikuje u Vivostat[®] aplikator gde se rastvor puferizuje. Direktno na jedinicu aplika-

sulting in the formation of a bioactive fibrin matrix. This procedure was repeated on day 43 to cover the remaining 2 cm diameter defect (Figure 3). Granula-



Slika 3. Stopalo nakon PRF tretmana

Figure 3. The foot after PRF treatment



Slika 4. Stopalo sa Tiersch-ovim transplantatom

tora se povezuje sterilan sistem koji poseduje opciju raspršivanja rastvora - sprej aplikator. Proces aplikacije traje 3–4 minuta i prilikom nanošenja spreja na defekt donornog mesta dolazi do momentalne polimerizacije i formiranja bioaktivnog fibrinskog matriksa. Ovaj postupak je ponovljen još jedanput, 43. dana, u drugom aktu, u cilju kompletnog pokrivanja zaostalog defekta, koji je iznosio 2 cm u prečniku (Slika 3). Na primenjene mere lečenja dolazi do formiranja granulacija nad dorzumom stopala, rana je bez znakova infekcije te je odlučeno da se pristupi pokrivanju defekta kože. Četrdeset sedmog dana od povrede, obavljena je nova

Figure 4. Foot with Thiersch transplant

tion tissue formed over the dorsal foot, and with no signs of infection, it was decided to proceed with skin defect coverage. On day 47, a new surgery was performed using a split-thickness autologous skin graft according to the Tiersch technique [7], with removal of K-wires (Figure 4). The donor site was on the anterior thigh of the contralateral leg, which was dressed aseptically. A skin graft mesh device is used to process the autologous skin graft, allowing for the creation of an adequate flap for application to the dorsal side of the foot.

Following the application of the Thiersch graft, the patient underwent regular dressing changes.



Slika 5. Stopalo sa Tiersch-ovim transplantatom

Figure 5. Foot with Thiersch transplant

operacija tokom koje je defekt kože dorzuma pokriven autotransplantatom kože prema Tiersch metodi [7], korišćenjem mesh graft- a prilikom čega su uklonjene K igle (Slika 4). Donorna regija anteriorne strane femoralne regije kontralateralne noge sa koje je uzet autotransplantat je sterilno previjen. Mesh graft uređajem se obradi kožni autotransplantat kako bi se dobio adekvatan flap za aplikovanje na dorzalnu stranu stopala.

Nakon primene Tiersch-ovog transplantata, pacijentkinja je redovno previjana. Na osnovu urednog lokalnog nalaza samog transplantata i donorne regije, odlučeno je da se lečenje pacijentkinje nastavi u kućnim uslovima, uz previjanje vazelinskim gazama i rivanolskim oblogama. Dve nedelje nakon otpusta iz bolnice, odnosno dva meseca od povrede, rane su zarasle, dozvoljen je oslonac na operisanu nogu (Slika 5), a pacijentkinja je upućena na dalju fizikalnu terapiju, koja je sprovedena u nadležnom rehabilitacionom centru narednih tri meseca. Šest meseci od inicijalne povrede, pacijentkinja je kompletno osposobljena za samostalni hod bez korišćenja pomagala.

DISKUSIJA

Lečenje otvorenih preloma stopala anatomskom repozicijom i fiksacijom K-iglama ostaju zlatni standard lečenja. Uobičajene hirurške komplikacije nakon ovakvih operacija uključuju odbacivanje implantanata ili iritaciju mekih tkiva, refrakturu, nesrastanje preloma, povredu senzitivnih grana nerva i hronični bol. Pacijenti treba da budu informisani o različitim opcijama lečenja i da budu deo procesa odlučivanja, posebno kada je vreme za oporavak i povratak prethodnim aktivnostima od suštinske važnosti [8].

Kod pedijatrijske populacije, otvorena repozicija i fiksacija K-iglama daje zadovoljavajuće rezultate bez pretećih komplikacija, prema postojećim podacima literature. Ranom hirurškom intervencijom, otvorenom repozicijom i blagovremenom rehabilitacijom kod mlađih osoba postiže se dobra redukcija preloma, a nakon rehabilitacije i pun opseg pokreta svih zglobova stopala i skočnog zgloba [9].

Otvoreni prelomi su povezani sa većom stopom infekcija i odloženim zarastanjem preloma, stoga su, pored fiksacije preloma važni i prevencija infekcije i praćenje lokalnog statusa mekih tkiva. Davanje antibiotika treba sprovesti što je ranije moguće i tokom 24–72 časa u zavisnosti od povrede. Inicijalni debridman i procena težine povrede određuju strategiju lečenja, naročito kod starijih osoba, kao u našem slučaju. Fiksacija preloma sledi opšte traumatološke principe. U slučajevima značajne kontaminacije, gubitka kosti ili velikog oštećenja mekog tkiva, vrši se privremena fiksacija i privremeno zatvaranje rane. Definitivni tretman

Based on the satisfactory local conditions of both the graft and the donor site, it was decided to continue the patient's treatment at home, using dressings with vaseline gauze and Rivanol compresses. Two weeks after hospital discharge and two months after the injury, the wounds had healed, and weight-bearing on the operated leg was permitted (Figure 5). The patient was then referred for continued physical therapy, which was carried out at the designated rehabilitation center over the following three months. Six months after the initial injury, the patient was able to walk independently without the use of assistive devices.

DISCUSSION

Open foot fractures treated with anatomical reduction and K-wire fixation remain the gold standard for treatment. Common complications include implant rejection or soft tissue irritation, refracture, nonunion, nerve injuries, and chronic pain. Patients should be informed about treatment options and included in decision-making, especially when return to function is a priority [8].

In pediatric cases, open reduction and K-wire fixation typically yield satisfactory results with minimal severe complications. Early surgical intervention and rehabilitation in younger patients usually result in sound fracture reduction and full joint mobility after therapy [9].

Open fractures are associated with a higher rate of infections and delayed fracture healing; therefore, in addition to fracture fixation, infection prevention and monitoring of the local soft tissue status are crucial. Antibiotic administration should be initiated as early as possible and continued for 24 to 72 hours, depending on the nature of the injury. Initial debridement and assessment of injury severity determine the treatment strategy, particularly in elderly patients, as in our case. Fracture fixation follows general traumatological principles. In cases of significant contamination, bone loss, or extensive soft tissue damage, temporary fixation and provisional wound closure are performed. Definitive soft tissue coverage should be achieved within 72 hours to reduce the risk of fracture-related infections. For segmental bone defects, various approaches are available to restore bone continuity, depending on the size of the defect and the local condition of surrounding structures such as tendons, nerves, and skin coverage defects [10].

Studies have shown that wound healing in elderly individuals is slower. Poor healing of chronic wounds in the elderly population is more often attributed to comorbidities rather than age alone [11]. Split-thickness

pokrivanjem mekog tkiva treba da se izvedu u roku od 72 h kako bi se smanjio rizik od infekcija povezanih sa prelomom. Za koštane segmentne defekte dostupni su različiti pristupi za obnavljanje kontinuiteta kosti, u zavisnosti od veličine i lokalnog nalaza okolnih struktura kao što su tetive, nervi, defekti kožnog pokrivača [10].

Istraživanja su pokazala da je zarastanje rana kod starijih osoba usporeno. Loše zarastanje hroničnih rana kod starije populacije češće se može pripisati komorbiditetu, a ne samo starosti. [11]. Kožni transplantati parcijalne debljine imaju prednost zato što sadrže manje tkiva koja zahtevaju revaskularizaciju nego kožni transplantati pune debljine kože. Stoga je veća verovatnoća da će biti uspešan na predhodno pripremljenom tkivu. Prednosti korišćenja kožnog transplantata parcijalne debljine kože su njihove veće šanse da prežive pod uslovima vaskularne kompromitacije, njihova relativno laka aplikacija, njihova sposobnost pokrivanja velikih kožnih defekata. Glavni nedostatak ovih graftova bio bi kozmetički u smislu boje kože, prisustvo granulacija na donorskim mestima koje zahteva posebnu negu. Graftovi su obično bez dlaka i znojenje je slabo zbog nedostataka adneksa kože [12].

Hiperbarična terapija (HBO) je primena 100% kiseonika na atmosferskim pritiscima, u cilju povećanja sadržaja kiseonika iznad fiziološkog nivoa, čime se stvaraju uslovi hiperoksije [9]. Hiperbarična terapija maksimizira prednosti kiseonika i povećava prirodne odbrambene mehanizme tela kako bi se poboljšalo zarastanje rana. To je odlična procedura za zarastanje rana, ali je treba koristiti samo kada je to opravdano. Da bi se koristila ova procedura na odgovarajući način, lekar mora da razume indikacije i kontraindikacije [13].

Vacuum assisted closure (V.A.C.) terapija koristi negativni pritisak kako bi se poboljšala cirkulacija u povređenom području i stimulisalo stvaranje granulacionog tkiva, što značajno ubrzava proces zarastanja [14]. Uklanjanjem viška tečnosti i eksudata, V.A.C. terapija smanjuje otok i olakšava optimalne uslove za zarastanje rane. Kontinuirano uklanjanje eksudata pomaže u uklanjanju devitalizovanog tkiva, tako da se i rizik od pojave infekcije smanjuje [14]. Stvara se zatvoreno okruženje koje pomaže u smanjenju nakupljanja bakterija, čime se smanjuje rizik od infekcije. Ovo je posebno korisno kod otvorenih rana i povreda koje su podložne kontaminaciji [13]. Mehanička stimulacija koju pruža negativni pritisak pomaže u formiranju granulacionog tkiva, ključnog za zarastanje rane, što pomaže u obnovi oštećenih struktura [15].

Proces zarastanja mišića i rana, kao i doprinos faktora rasta procesu zarastanja je oblast koja se intenzivno proučava. Koncentrisanjem ovih faktora rasta, PRF može poboljšati procese zarastanja. Neke od prvih

skin grafts have an advantage because they contain less tissue requiring revascularization compared to full-thickness skin grafts. Therefore, they are more likely to succeed on previously prepared tissue.

The advantages of using split-thickness skin grafts include a higher likelihood of survival under conditions of vascular compromise, relatively easy application, and their ability to cover significant skin defects. The main disadvantage of these grafts is cosmetic, including differences in skin color and the presence of granulation tissue at donor sites, which requires special care. The grafts are typically hairless and exhibit reduced sweating due to the absence of skin adnexa [12].

Hyperbaric oxygen therapy (HBO) involves administering 100% oxygen under increased atmospheric pressure to elevate oxygen levels above physiological norms, thereby creating conditions of hyperoxia [9]. HBO maximizes the benefits of oxygen and enhances the body's natural defense mechanisms to promote wound healing. It is an effective wound healing procedure, but should only be used when clinically justified. To apply this treatment appropriately, the physician must understand its indications and contraindications [13].

Vacuum-assisted closure (V.A.C.) therapy utilizes negative pressure to enhance circulation in the injured area and stimulate the formation of granulation tissue, thereby significantly accelerating the healing process [14]. By removing excess fluid and exudate, V.A.C. therapy reduces swelling and facilitates optimal wound healing conditions. Continuous exudate removal also helps eliminate devitalized tissue, thereby reducing the risk of infection [14]. It creates a closed environment that helps decrease bacterial accumulation, thereby lowering the risk of infection. This is especially beneficial for open wounds and injuries prone to contamination [13]. The mechanical stimulation provided by negative pressure supports the development of granulation tissue, which is essential for wound healing and the restoration of damaged structures [15].

The process of muscle and wound healing, as well as the role of growth factors in this process, is an area of intense research. By concentrating these growth factors, PRF can enhance healing processes. Some of the first studies to demonstrate this were conducted by Wright-Carpenter and colleagues, who evaluated the effects of PRF on muscle injuries in humans. The study showed that the recovery time of patients treated with PRF was reduced to 16.6 days, compared to 22.3 days for patients treated with conventional methods. This supported the use of PRF during patient treatment, confirming earlier observations from animal models and in vitro studies [16].

studija koje su ovo otkrile izveli su Rajt-Karpenter i saradnici koji su procenili efekte PRF-a na povrede mišića kod ljudi. Studija je pokazala da je vreme oporavka pacijenata tretiranih PRF smanjeno na 16,6 dana u poređenju sa 22,3 dana kod pacijenata lečenih konvencionalnim metodama. Ovo je podržalo upotrebu PRF-a tokom lečenja pacijenta, potvrđujući prethodna zapažanja na životinjskim modelima i *in vitro* studijama [16].

Prema eksperimentalnoj studiji koju su izveli M. Cianiforlini i saradnici, proces zarastanja nakon direktne ili indirektno povrede mišića su složeni, ali jasno definisan i uključuje dobro koordinisane korake: degeneraciju, upalu, regeneraciju i fibrozu. Uprkos ovoj čestoj pojavi i prisustvu velikog broja podataka o patofiziologiji povreda mišića, nijedna od trenutnih strategija lečenja se nije pokazala stvarno efikasnom u strogo kontrolisanim ispitivanjima. Plazma bogata trombocitima (PRP) je obećavajući alternativni pristup zasnovan na sposobnosti autoloških faktora rasta (GF) da ubrzaju zarastanje tkiva, poboljšaju regeneraciju mišića, povećaju neovaskularizaciju i smanje fibrozu. Ova studija je fokusirana na upotrebu različitih koncentracija PRP-a kao izvora faktora rasta [17].

Fibrin bogat trombocitima (PRF) je bogat faktorima rasta koji stimulišu proliferaciju ćelija, što doprinosi bržem zarastanju kože i mekih tkiva. Ovi faktori rasta poboljšavaju regeneraciju tkiva i sintezu kolagena, što dovodi do čvrstog i elastičnog zarastanja. Primećeno je da PRF sadrži 23% više koncentracije leukocita od obične plazme, koji pomažu u kontroli mikroba u rani i smanjenju rizika od infekcije [18]. Kada se PRF koristi kao dodatak prilikom presađivanja tkiva, povećava se verovatnoća uspešne integracije grafta i smanjuje rizik od odbacivanja, što može značajno doprineti ishodu lečenja [19].

Terapija rana negativnim pritiskom je dramatično promenila negu složenih rana na stopalima. U poređenju sa standardnom negom rana, pacijenti sa ranama dijabetičkog stopala koji se leče terapijom negativnim pritiskom imaju 5,9 puta veću verovatnoću da će zarasti i 4,4 puta manje šanse da će zahtevati amputaciju. Terapija negativnim pritiskom povećava perfuziju rane, ubrzava formiranje granulacionog tkiva, smanjuje edem i smanjuje bioopterećenje [20].

Kishore Vellingiri i saradnici, su prikazali slučaj lečenja pacijenta sa povredom stopala i upotrebom V.A.C. terapije. Navedeni pacijent je povređen u saobraćajnom traumatizmu prignječenjem, zadobio je povredu kalkaneusa sa gubitkom dela koštanog tkiva i oštećenjem loknog tkiva. Autori su primetili da benefiti značajno nadmašuju troškove V.A.C. sistema, što ga čini osnovnom opcijom lečenja za pacijente sa ovakvim vrstama povrede [21].

According to an experimental study conducted by M. Cianiforlini and colleagues, the healing process following direct or indirect muscle injury is complex yet clearly defined, comprising well-coordinated phases: degeneration, inflammation, regeneration, and fibrosis. Despite the frequent occurrence of such injuries and the abundance of data on the pathophysiology of muscle damage, none of the current treatment strategies has proven truly effective in strictly controlled trials. PRP is a promising alternative approach based on the ability of autologous growth factors (GFs) to accelerate tissue healing, enhance muscle regeneration, increase neovascularization, and reduce fibrosis. This study focused on the use of different concentrations of PRP as a source of growth factors [17].

Platelet-Rich Fibrin is rich in growth factors that stimulate cell proliferation, thereby contributing to faster healing of skin and soft tissues. These growth factors enhance tissue regeneration and collagen synthesis, leading to firm and elastic wound healing. It has been observed that PRF contains 23% higher leukocyte concentration compared to regular plasma, which helps control microbial presence in the wound and reduces the risk of infection [18]. When used as an adjunct during tissue grafting, PRF increases the likelihood of successful graft integration and reduces the risk of graft rejection, which can significantly contribute to treatment outcomes [19].

Negative pressure wound therapy (NPWT) has dramatically changed the management of complex foot wounds. Compared to standard wound care, patients with diabetic foot wounds treated with NPWT are 5.9 times more likely to achieve wound closure and 4.4 times less likely to require amputation. NPWT increases wound perfusion, accelerates granulation tissue formation, reduces edema, and lowers the bioburden [20].

Kishore Vellingiri and colleagues presented a case of foot trauma treated with V.A.C. therapy. The patient sustained a calcaneal injury with bone loss and local tissue damage due to a crush injury in a traffic accident. The authors noted that the benefits of the V.A.C. system significantly outweigh its costs, making it a primary treatment option for patients with such injuries [21].

The combination of V.A.C. therapy and PRF enables efficient wound healing, reduces the risk of infection, and provides optimal wound bed preparation for further reconstructive surgery, thereby improving treatment success in cases of complex soft tissue injuries and open fractures, as demonstrated in the treatment of the presented patient.

Kombinacija V.A.C. terapije i PRF-a omogućava efikasno zarastanje, smanjenje rizika od infekcija i optimalnu pripremu rane za dalju rekonstruktivnu hiruriju, čime se povećava uspešnost lečenja kod složenih povreda mekih tkiva i otvorenih preloma, što je i postignuto prilikom lečenja navedene pacijentkinje.

ZAKLJUČAK

Pravovremena primena inicijalnog operativnog lečenja na sam dan povrede, u kombinaciji sa specifičnim terapijskim metodama i multidisciplinarnim pristupom, bila je ključna za postizanje visokog kvaliteta nege i optimalnog ishoda kod pacijentkinje starije životne dobi. Prva operacija, koja je obuhvatala ispiranje, debridman i stabilizaciju preloma, stvorila je osnovu za uspešan oporavak, smanjujući rizik od infekcije i komplikacija koje bi mogle dodatno ugroziti stanje pacijentkinje.

Starija životna dob sa sobom nosi povećan rizik od usporenog zarastanja i komplikacija, što čini brzu intervenciju i stalno praćenje još važnijim. Multidisciplinarni pristup omogućio je precizno planiranje i pravovremeno sprovođenje dodatnih terapija, kao što su hiperbarična oksigenacija, V.A.C. terapija i PRF tretman. Ovakav integrisani model lečenja, prilagođen specifičnim potrebama pacijentkinje, predstavlja primer značaja sveobuhvatne nege koja obuhvata sve aspekte oporavka, čime su maksimalizovane šanse za potpuni funkcionalni oporavak čak i kod pacijenata sa složenim povredama u starijoj životnoj dobi.

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CONCLUSION

The timely initiation of surgical treatment on the day of injury, combined with specific therapeutic methods and a multidisciplinary approach, was crucial in delivering high-quality care and achieving an optimal outcome in this elderly patient. The initial surgery, which included irrigation, debridement, and fracture stabilization, laid the groundwork for successful recovery by minimizing the risk of infection and other complications that could have further compromised the patient's condition.

Advanced age carries an increased risk of delayed healing and complications, making prompt intervention and continuous monitoring even more important. The multidisciplinary approach enabled precise planning and timely implementation of additional therapies, including hyperbaric oxygen therapy, V.A.C. therapy, and PRF treatment. This integrated treatment model, tailored to the patient's specific needs, exemplifies the importance of comprehensive care that addresses all aspects of recovery, maximizing the chances for complete functional restoration even in elderly patients with complex injuries.

Conflict of interest: None declared.

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