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Soft tissue defect closure using an Ilizarov frame: a case series

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The Ilizarov technique is a well-known procedure for limb deformity corrections. However, in the present study, the purpose was to examine the potential of wound closure by means of an Ilizarov frame.
Two main cases are presented, a further seven were retrospectively reviewed. The first case experienced a chronic wound at the tibial tuberosity. A fistula was excised followed by antibiotic therapy, however, dehiscence at the wound occurred for which an Ilizarov procedure was used. After two weeks the frame was removed and the wound was closed. The second patient underwent osteosynthesis of a tibia and fibula fracture but was complicated by infection. An Ilizarov device was applied for bone healing as well as the skin defect.
Nine patients were included in total. Four of them attained enough skin length via the Ilizarov procedure for secondary closure. Three had the frame removed before having full wound covering and needed further granulation of the wound. Finally, two more patients underwent graft reconstruction. Three patients suffered from infectious complications.
The gold standard in soft tissue closure remains skin or flap reconstruction, however, this is not advisable in poor overall health and decreased local vascularity. If an Ilizarov frame is present for bone reconstruction, it can simultaneously be used for skin closure. The results shown in the current study indicate that a satisfactory outcome can be achieved.

Keywords: Ilizarov, soft tissue defect, wound closure, skin transport.

INTRODUCTION

The Ilizarov external fixation technique is a well-known and successful procedure in limb deformity corrections[1]. Although this technique is well documented in medical literature for bony transport, evidence concerning Ilizarov assisted soft tissue transport is scarce. Soft tissue defects resulting from severe trauma often cannot be closed by primary wound suturing. Modern split thickness skin graft, rotational or free microvascular flap reconstruction surgery is sometimes required for full defect coverage. In certain situations, however, flap reconstruction cannot be used. These cases include elaborate zones of injury, loss of local blood supply and compromised general health[2].

In properly selected cases, distraction forces achieved by the Ilizarov method can accommodate and remodel soft tissue structures[3]. Consequently, this technique could be of great value in complex wound closure especially in patients having an Ilizarov device in place for complex bone union.

In the present study, we report a case series in which an Ilizarov frame was applied and used as an effective wound closure method. The purpose of this technique was to achieve wound coverage in soft tissue defects that cannot be closed per primam and where conventional reconstruction techniques are not applicable. The aim of this case series is to evaluate the results, the complications and risk factors of this alternative technique.

CASE PRESENTATION

Between 2001 and 2017, nine procedures were performed to close a skin defect using an Ilizarov frame adjusted to put traction on the skin and to achieve secondary wound closure. Two cases are elaborated further. The remaining seven cases can be found in Table I.

Table I. — Cases

Patient	Age (at the time of surgery)	Comorbidities: risk factors	Indication	Surgery	Size wound	Evolution	Secondary closure	Complications
1 (main case)	56	IDDM type 2 Smoker	Chronic wound leakage after insertion of a knee arthrodesis performed following an infected nonunion around an intramedullary tibia nail.	Day 0: Construction of an Ilizarov frame over the right distal tibia for progressive skin closure and future bone transport	8 cm x 3 cm	After 14 days: 7 cm x 0 cm	After 2 weeks: Stop Ilizarov frame. Secondary closure of the wound.	/
2	45	Smoker Ethyl Cannabinoids	Complex open fracture treated with bimalleolar ORIF. Fasciotomy because of postoperative compartment syndrome.	Day 0: VOS and construction of an Ilizarov frame for progressive skin closure and future bone transport.	23 cm x 6 cm	After 10 days: 22cm x 6 cm After 3 weeks: 20cm x 5 cm After 5 weeks: 20 cm x 4 cm After 2,5 months: 15 cm x 3 cm	After 2,5 months: stop Ilizarov Frame. Wound granulation. After 9 months: healed	After 5 months: infection treated with antibiotics
3	59	Smoker Avulsion tibial nerve and posterior tibial artery	Open tibial fracture Gustillo 3B treated with external fixation. Infected wound medial distal tibia.	Day 0: Removal external fixation and constructing Ilizarov frame for progressive skin closure and for future bone transport.	8cm x 8 cm (posterior) 5cm (anterior)	- After 7 days: 8 cm x 7 cm (posterior), x 4 cm (anterior) - After 4 weeks: 8 cm x 6 cm (posterior) x 3 cm (anterior) - After 6 weeks: 8 cm x 4 cm (posterior) x 1 cm (anterior) - After 7 weeks: 5 cm x 4 cm (posterior) closed anterior	- After 2,5 months: stop Ilizarov Frame, wound granulation (4 cm x 2 cm) - After 3,5 months: wound granulation (3 cm x 1 cm) - After 5,5 months: wound granulation (1 cm x 1 cm)	/
4	24	/	Complex open fracture of the forearm with a large skin defect.	09/07/2001: Start progressive skin closure using an Ilizarov frame	Unknown	Unknown	After 2 weeks: Closure of the wound	/
5	22	Smoker	Open tibial fracture Gustillo 3B left treated primarily with an intramedullary nail and cerclage treads with progression to necrosis and infection.	Day 0: Resection of the infected and avital segment, constructing Ilizarov frame for progressive skin closure and for future bone transport. Day 10: Start progressive skin closure.	30cm x 15cm	After 4 weeks: 27cm x 15cm After 6 weeks: 10cm x 2cm	After 2 months: stop closure wound with Ilizarov. Wound granulation (15cmx7cm) After 5 months: latissimus dorsi flap reconstruction	After 6 months: Infection of the donorsite.
6	47	Smoker	Right open ankle fracture Gustillo 3B, with a communitive pilon tibial, primarily treated with PSOS followed by osteomyelitis with resection of the infected segment.	Day 0: Resection of infected segments, construction of an Ilizarov frame for progressive skin closure and future bone transport.	11cm x 3cm	After 1 month: 11cm x 0cm	After 5 weeks: Closure of the wound	/
7	32	Cannabinoïds	Fracture of the left distal femur Gustillo 3B, primarily treated with an ex-fix, later on with a plate. Due to infection the material needed to be removed and the infected segment needed to be resected leaving behind a wound defect.	Day 0: Construction of an Ilizarov frame for progressive skin closure with a bone transport in the future.	10cm x 5cm	After 1 month: 9cm x 4cm	After 5 weeks: removing frame and applying approximating sutures. At the moment the wound is still healing.	/
8	49	/	Posttraumatic tibiotalar arthritis of the right ankle following a bimalleolar fracture with failure of the PSOS. The arthritis was treated by an arthrodesis with postoperatively infection of the wound	Day 0: Construction of an Ilizarov frame for progressive skin closure.	15 cm x 3 cm	After 10 days: 6cm x 3cm	After 10 days: remaining wound was closed using a split thickness graft.	/

9	26	IDDM type 1	A left distal tibial fracture treated with an IM-nail with need of fasciotomy because of an acute compartment syndrome. Progression to an infected non-union (MRSA).	Day 0: Resection of infected segment, construction of an Ilizarov frame for stabilization and progressive wound closure and future bone transport after 3 months.	31 cm x 7cm	After 12 days: 31 x 2-3cm After 20 days: 31 cm x 1-2cm	After 1 month: Secondary closure of the wound	Mild proximal wound leakage, positive for MRSA, postponed the bone transport.

IDDM (insulin dependent diabetes mellitus), VOS (removal osteosynthesis), cm (centimeters), IM (intramedullary), ORIF (open reduction internal fixation), ex-fix (external fixator), MRSA (methicillin resistant staphylococcus aureus).

Case 1

As our main case we present a fifty-six-year-old male with insulin dependent diabetes mellitus (IDDM) who presented at our department with persisting wound leakage at the right proximal tibia. The patient endured an injury in 2010. He fractured his right tibial plateau and the distal portion of his right femur. Initially the knee fracture was fixated by plate and screw osteosynthesis using autologous fibula graft insertion. Because of a skin defect an ALT (anterolateral thigh) free flap was placed on the proximal tibia. Since a postoperative infection of the fixation material occurred, the plate and screws were removed in February 2011. At that time, an antibiotic coated cement spacer was inserted until the infection was eradicated. In July of 2011 the spacer was removed and a knee arthrodesis was performed with an intramedullary nail. The operative wound was primary closed (Figure 1). In the years following, anterior knee pain in the proximal tibia continued to exist without evidence for underlying infection.

In April 2016 the patient consulted our department with an evacuating wound situated at the right proximal tibia in the region of the tibial tuberosity. The patient endured local pain with edema and redness around the wound. Antibiotic therapy was started by his general practitioner. X-ray imaging showed no evidence of loosening or bone destruction. Ultrasound showed an underlying fluid collection of 1.9 by 3.2 centimeters with fistulation to the skin. At the end of July, bone biopsies were performed to identify the cause of infection. The biopsies were taken after a two-week antibiotic-free interval but no causal germs were identified. Bone scintigraphy and white blood cell scan did not show any infectious focus. Considering this it was decided to perform an excision of the fistula with another set of bone biopsies. The procedure took place at the end of March 2017. The wound was primary closed and antibiotics were prescribed again. The bone biopsies showed infection with Staphylococcus mitis. The initially prescribed Vancomycin was then switched to Clindamycin for a total duration of six weeks. During hospitalization, there was dehiscence of the medial part of the wound (Figure 2). To assure permanent closure of the wound defect it was decided to perform an Ilizarov procedure to progressively close the skin (Figure 3).

Figure 1. — Primary closure of the wound.

Figure 2. — Dehiscence of the medial part of the wound after infection.

Figure 3. — The Ilizarov device to close the defect.

Figure 4. — Per secundam closure of the wound.

Six Ticron 5 threads were applied to the proximal edge of the wound and were then sutured to an extra added rod that was parallel and distally to the longitudinal edge. The proximal edge was chosen because it had a surplus of skin compared with the distal edge. Traction on the skin was obtained by daily rotating the bolts of the extra rod three times a day for a total lengthening of 0,75 mm a day. After 14 days of traction the frame could be removed and the wound could be sutured per secundam (Figure 4). No post-closure complications were noted.

Case 2

We further present a second case of a 45-year-old male patient who had a tibial and fibular fracture of the right leg in January 2013. He was transferred to our department after he endured a compartment syndrome after initial open reduction and internal fixation (ORIF). A fasciotomy was performed elsewhere. After this fasciotomy, the ORIF was revised and the medial and lateral wounds were partially closed. Three days after partial closure, the wounds got infected and the osteosynthesis material was clearly visible. Cultures showed Pseudomonas aeruginosa, Klebsiella pneumoniae and Enterobacter cloacae. Wound debridement was necessary up to four times. After the transfer to our hospital, surgery was performed to remove the plate and screws and resect the tibial pilon and the distal part of the fibula. Stabilization of the right lower leg was achieved by constructing an Ilizarov frame. On this frame we attached Ticron 5 threads and sutured them to the skin edges under traction. By winding the rods, it was tried to gradually stretch and simulate wound closure by stimulating horizontal skin tissue growth. The same protocol as the prior case was used. The rods were rotated three times a day per ratio of 0.25 mm per rotation.

Following this surgical procedure, the medial wound had to be debrided and three of the Ticron threads had to be replaced. The lateral wound showed no signs of infection. The infection was treated with antibiotics following antibiogram that resulted from perioperatively harvested cultures. After a total therapy duration of two and a half months, with respect to the wound closure, the frame was removed and the wound was left open for natural granulation.

Five months after the start of the progressive wound closure, the open wound suffered from infection once again. This infection was also treated with antibiotics according to the results of the antibiogram. Finally, after nine months the wound was closed.

RESULTS

A total of nine patients were treated via an Ilizarov method because of skin defects. The age of the patients varied between 22 years and 56 years of age (mean age: 40 years old). They were all male. Of the 9 patients treated for a skin defect using an Ilizarov frame, four patients reached a sufficient skin edge length that was suitable for secondary closure. In three of them the frame was removed before full skin approximation followed by closure of the wound by secondary healing. These patients achieved skin closure through tissue granulation. Two of the patients needed an additional flap reconstruction to cover the remaining skin defect after removal of the frame. Three of the treated patients suffered from postoperative complications: two infections of the wound that were resolved with

adequate antibiotic therapy and one infection of the donor site in a patient who was treated with additional flap reconstruction. The latter was also successfully eradicated using adequate antibiotics. All but two had one or more risk factors for aberrant wound healing. The most important risk factors were smoking and diabetes mellitus. Further details are explained in Table I.

DISCUSSION

Gavriil Abramovich Ilizarov started his career in western Siberia by treating patients who had returned with fractures from World War II. During the 1950s, Ilizarov began experimenting with external fixation designs. He successfully treated his first patient in 1954. It was a factory worker with a tibial non-union. During this time, he discovered by chance distraction osteogenesis for bone lengthening because he observed callus formation in a patient who had mistakenly distracted his frame instead of compressing it. Afterwards his methods were released and studied worldwide, however, he kept enduring opposition from the medical establishment in Russia up until his death[1,4].

Currently, the Ilizarov technique is used for limb deformity corrections and has been studied extensively for bone defects and transport[5,6]. However, it can also be used for deformations in different planes when associated with an osteotomy[7]. Nevertheless, the present case series confirms the possibility to use it for other purposes, such as secondary wound closure. Severe trauma cases are often characterized by extensive destruction of both bone and soft tissues. In the past, the main goal was to cover the defect, preferably by a muscular flap[8]. However, recent discoveries have shown that a fascio-cutaneous flap can be equally effective[9]. These flaps have proven to decrease infection risk and increase vascularity to the bone. Also, high energy trauma patients can develop a compartment syndrome. This is usually treated by a fasciotomy to release intra-compartmental pressure. The resulting skin defect needs to be covered afterwards to prevent further complications[10].

The biomechanics of wound closure using an Ilizarov device are based on two visco-elastic properties of skin growth. Firstly, creep (elongation of skin with a constant load over time) and secondly stress-relaxation (the amount of force required to maintain stretch at a certain length decreases over time). Creep can be further subdivided in a mechanical (the skin's ability of acute lengthening) and a biological (formation of new skin secondary to chronic stretching) group. An increased cellular activity can be seen which thickens the epidermis. At the same time the dermis decreases in thickness, the adipose and muscle tissue becomes thinner as well. Remarkably though, the thinner muscle fibers have no functional loss and the strength remains identical. Finally, existing vascular structures lengthen with the skin and a boost in angionesis can be perceived. These pathways are essential for further skin lengthening. After two years all tissue layers have returned to their original dimensions[3,11].

In our opinion, the Ilizarov frame can be seen as a valuable alternative for gold standard treatments. Large soft tissue defects are usually cured with flap reconstruction surgery, the two mainly used subtypes are free flaps and pedicled flaps[12]. Alternatively negative pressure therapy can be used if the defect is less extensive. However, when there is a large soft tissue defect or the patient has a suboptimal vascular status and thus flap surgery is contra-indicated, the Ilizarov frame can be used. Furthermore, if performing an autologous skin transplantation, a fragile donor site is created which can present complications of its own[13]. One of the main risk factors seen in flap surgery is impaired healing of the donor sited due to infection or bad vascular status. The favorable environment created by the Ilizarov which covers the defect with autologous healthy skin also strongly decreases the chance of tissue necrosis.

In conclusion, the Ilizarov frame is a good option in well-chosen selected cases in which a (mutilating) flap reconstruction can be avoided. Additionally, the lack of exposure in the affected area caused by the wires and rings of the Ilizarov complicates a flap reconstruction, and especially the microsurgical anastomoses. Furthermore, the excellent properties of the Ilizarov devices concerning bone healing are another advantage of this approach[14,15]. On the other hand, infection could also occur using the Ilizarov technique. Additionally, the same risk factors of flap rejection also apply to wound closure with an Ilizarov frame. Patients who smoke and/or suffer from diabetes mellitus will have a greater risk of persistent wound problems as these factors impede proper wound healing. Patients should be motivated to quit smoking and attain controlled levels of glycemia to obtain the best results[16,17]. Obviously, the skin edges next to the deficit also need to be of adequate quality since they can pose problems in patients with skin disease or chronic steroid usage[15]. Furthermore, it should be emphasized that soft tissue closure with an Ilizarov device will never replace flap reconstruction, which still is the gold standard. The main benefit of an Ilizarov frame lays in the possibility to combine wound

closure and deformity correction at the same time. The frame can be used to close wounds progressively when it is already applied for bony reconstruction. The application of a frame specifically for wound closure is obviously not the goal[18]. Ideally, close communication and collaboration between the plastic surgeon and the orthopedic surgeon is necessary to decide the optimal course of treatment following severe bone and soft tissue damage. If infection is present, a microbiologist should be consulted as well[13].

Limitations of this study are the small sample size of nine patients. Also, several confounding factors were present which could affect the outcome of the soft tissue closure. Nevertheless, this study suggests and underlines the value of the Ilizarov technique for soft tissue defects.

CONCLUSION

In conclusion, closure of soft tissue defects using an Ilizarov frame can be optional in selected cases and can yield excellent results. In the authors' opinion, the patient should be treated for bone transport using the Ilizarov method and flap reconstructive surgery for wound closure should be contra-indicated before using this approach. This method should however not be seen as an alternative to flap reconstruction but more as an add-on if an Ilizarov device is already present. It should be noted that risk factors of wound closure still apply here and a collaboration between plastic surgery and orthopedics is mandatory. With this case series we presented a relatively unknown yet possible method for wound closure by secondary healing by using an Ilizarov frame.

REFERENCES

1. Spiegelberg B, Parratt T, Dheerendra SK, Rennings R, Marsh DR. Ilizarov principles of deformity correction. Ann R Coll Surg Engl. 2010 Mar; 92 (2): 101-105.
2. Khan U, Pickford M. Use of an islanded fasciocutaneous flap in the lower limb following distraction callotasis. Br J Plast Surg. 2000 Dec;53(8):705-6.
3. Bibbo C, Subash K, Albright J. Ilizarov wound closure method for traumatic soft tissue defects. Foot Ankle Int. 2010 Jul;31(7):628-633.
4. Aktuglu K, Kubilay E, Arman V. Ilizarov bone transports and treatment of critical-sized tibial bone defects: a narrative review. J Orthop Traumatol. 2019 Apr 16; 20(1): 22.
5. Demir B, Oztruk K, Oke R, Gursu S, Aydin KB, Sahin V. A modified technique of internal bone transport. Acta Orthop Belg. 2008 Apr;74(2):216-221.
6. Chaddha M, Gulati D, Singh AP, Maini L. Management of massive posttraumatic bone defects in the lower limb with the Ilizarov technique. Acta Othop Belg. 2010 Dec;76(6):811-820.
7. Stanitski DF, Bullard M, Armstrong P, Statinksi CL. Results of femoral lengthening using the Ilizarov technique. J Pediatr Orthop. 1995;15(2):224-231.
8. Hong SW, Seah CS, Kuek LBK, Tan KC. Soft Tissue Cover in Compound and Complicated Tibial Fractures Using Microvascular Flaps. Ann Acad Med Singapore. 1998 Mar;27(2):182-187
9. Hatz BA, Frima H, Sommer C. Selective fasciotomy for acute traumatic lower leg compartment syndrome: is it feasible? Arch Orthop Trauma Surg. 2019 Dec; 139(12):1755-1762.
10. Mullen J, Rozbruch R, Blyakher A, Helfet D. Ilizarov method for wound closure and bony union of an open grade IIIB tibia fracture. Case Rep Clin Pract Rev. 2004; 5(1).
11. Velnar T, Bailey T, Smrkolj V. The wound healing process: an overview of the cellular and molecular mechanisms. J Int Med Res. 2009;37(5):1528-1542.
12. Koh K, Goh T, Song CT, Hyun SS, Rovito P, Hong JP, Hallock G. Free versus Pedicled Perforator Flaps for Lower Extremity Reconstruction: A Multicenter Comparison of Institutional Practices and Outcomes. J Reconstr Microsurg. 2018 Oct; 34(8):572-580.
13. Lerner A, Ullmann Y, Stein H, Peled IJ. Using the Ilizarov external fixation device for skin expansion. Ann Plast Surg. 2000 Nov;45(5):535-537.
14. Kocialkowski A, Marsh DR, Shackley DC. Closure of the skin defect overlying infected non-union by skin traction. Br J Plast Surg. 1998 Jun;51(4):307-310.
15. D'hooghe P, Defoort K, Lammens J, Stuyck J. Management of a large post-traumatic skin and bone defect using an Ilizarov frame. Acta Orthop Belg. 2006, 72, 214-218.
16. Kean J. The effects of smoking on the wound healing process. J Wound Care. 2010 Jan; 19(1):5-8.
17. Sharp A, Clark J. Diabetes and its effects on wound healing. Nurs Stand. 2011 Jul 13-19; 25(45):41-47
18. Topliss C, Jackson M, Atkins RM. Dermal traction on the Ilizarov frame. Injury. 2005 Jan;36(1):194-198.