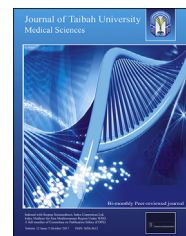




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Original Article

Massive segmental bone loss due to pantibial osteomyelitis in children reconstructed by medial fibular transport with Ilizarov frame



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المخلص

أهداف البحث: نقل الشظية بالأوعية الدموية أو من غير الأوعية الدموية هو إجراء جديد من إجراءات إنقاذ الأطراف، ولكنه ارتبط بمعدلات فشل ومضاعفات عالية. نقل الجزء الإنسي من الشظية بنفس الجهة باستخدام جهاز إيلزاروف هو تعديل الإجراء الجراحي لمنع المضاعفات وزيادة فرص النجاح. وتعرض هذه المقالة أكبر سلسلة من إنقاذ الأطراف لفقدان جزء كبير من العظم الظنبوبي لدى الأطفال بسبب التهاب العظم والنقي الكامل، بواسطة نقل الجزء الإنسي من الشظية بنفس الجهة بجهاز إيلزاروف.

طرق البحث: نَصَف في هذه المقالة سلسلة من الحالات ل ١٢ مريضاً بمتوسط عمر ١٢ عاماً (٦-١٨). في المرحلة الأولى من الجراحة، تم استئصال جميع العظم الميت، وتم تثبيت جهاز إيلزاروف من غير شد. وفي المرحلة الثانية، عادة بعد شهر من إعادة التشكيل تتم بواسطة النقل التدريجي للجزء الإنسي للشظية في نفس الجهة باستخدام جهاز إيلزاروف للشد بواسطة أسلاك الزيتون، بعد عمل القص العظمي للجزء القاصي والداني للشظية. في المرحلة الثالثة، تم تنضير مواقع استقبال الظنوب للشظية. وكان الحد الأدنى للمتابعة عامين.

النتائج: يصحب تحمل كامل الوزن تضخم في حجم الشظية المنقولة، وحركة مرضية للمفصل تحدث عند جميع المرضى. وإزالة العظام المحجوزة تؤدي إلى التحكم في الالتهاب في ١٧.٢٧ ± ٧.٧٦ يوماً. يأخذ نقل الشظية ٥٨.١٦ ± ١٤.٤ يوماً. وكان طول الجزء المفقود من عظمة الظنوب والمستبدل بالشظية ٩.٥ ± ٢.٢٣ سم. بينما كان متوسط الأيام اللازمة لإتحاد العظام بعد تنضير موقع الاستقبال ٧٦.٥٨ ± ٦.٢ يوماً.

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الاستنتاجات: يعمل إطار اليزاروف للالتهاب الكامل للعظم والنقي الظنبوبي بواسطة استئصال العظم ونقل الجزء الإنسي من الشظية بشكل جيد لإنقاذ الأطراف عند الأطفال.

الكلمات المفتاحية: نقل الشظية؛ تضخم؛ إيلزاروف؛ التهاب العظم والنقي؛ البتر

Abstract

Objectives: Vascularized or non-vascularized fibula transport is a novel procedure for limb salvage but has been associated with high failure rates and complications. Ipsilateral medial fibular transport (IMFT) using Ilizarov apparatus is a modification of the procedure to prevent complications and increase success rate. This article presents the largest series of limb salvage for massive tibial bone loss in children due to pan-osteomyelitis by IMFT with Ilizarov apparatus.

Methods: A case series of 12 patients with a mean age of 12 (6–18) years is described. At the first stage of surgery, the excision of all dead bone was performed, and Ilizarov without traction apparatus was applied. In second stage, ipsilateral fibula is gradually transferred to tibial defect with the help of ilizarov olive wires. In the third stage, the freshening of docking sites of fibula to tibia was performed. The minimum follow up was of two years.

Results: Hypertrophy of the transported fibula accompanied by full weight bearing and satisfactory joint motion occurred in all patients. Removal of sequestered bone resulted in control of infection in 27.17 ± 7.76 days. Fibular transport took 16.58 ± 4.14 days. The length of

tibial bone loss replaced by fibula was 9.50 ± 2.23 cm. The mean days required for union after freshening of the docking site was 76.58 ± 6.20 days.

Conclusions: Ilizarov frame for pan tibial osteomyelitis with bone excision and medial fibular transport works well for limb salvage in children.

Keywords: Docking; Fibular transport; Hypertrophy; Ilizarov; Osteomyelitis

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Introduction

Chronic osteomyelitis usually results from poorly treated or untreated acute osteomyelitis, open fractures, orthopaedic surgeries or infected soft tissue spread.¹ Chronic osteomyelitis is seen much more frequently in developing countries compared to the developed world.² In developing countries, such as Pakistan, several factors contribute to this condition, including virulent pathogenic bacteria in these countries; late presentation; poor nutritional and immune status of the patients; low socio-economic status and relatively poor access to antibiotic drugs.³ The long bones are affected most commonly, and the femur and tibia account for approximately half of the cases.⁴ Boys are affected twice as much as girls.⁵

The diagnosis and management of chronic osteomyelitis is still a challenge for orthopaedic surgeons.⁶ Amputation was considered as a simple solution for management of these patients in the past but it is not always acceptable to patients and relatives.⁷ Although several investigators have reported that the initial hospitalization costs are considerably less for amputation than for limb salvage,⁴ others suggested that the long-term costs of amputation are more than limb salvage because of the prosthesis needs.^{8,9}

The treatment strategy for chronic osteomyelitis has changed significantly over the past twenty years.¹⁰ Various techniques have been introduced to treat large segmental tibial defects such as autogenous cortical bone grafts, tibiofibular synostosis, ipsilateral fibular graft with or without Ilizarov apparatus, allograft reconstruction, vascularized free fibula transfer and bone transport.¹¹

Ipsilateral transport of fibula is a novel option in limb salvage surgery for patients with large tibial defects.¹² Ipsilateral fibular graft to treat massive tibial bone loss was first credited to Hanh in 1884.⁶ In 1905, Huntington described the transfer of a whole segment of fibular graft in two stages to bridge a tibial defect.¹³ In 1998, the method of ipsilateral fibular transport was introduced with the Ilizarov frame, describing its application in three patients with massive tibial bone loss (range, 13–28 cm).¹² In the same year, Kim et al. reported the use of a ring fixator to

transport a fibular segment to replace a 17-cm tibial bone loss in one patient.¹²

We questioned whether ipsilateral medial fibular transport with the Ilizarov frame could result in replacement of massive tibial bone loss and hypertrophy of the ipsilateral transported fibula in children, due to pan osteomyelitis. This study is the largest reported series in literature and also suggested some modifications in previous reported surgical method of fibular transport using ilizarov apparatus.

Materials and Methods

This prospective descriptive study was conducted on twelve patients with a mean age of 8.25 ± 2.59 (range 4–12) years at our institution. Seven male and five female patients were selected between 2007 and 2014. The lowest defect was 5 cm, and the highest defects were 12 cm with a mean of 9.52 cm and SD of 3.23 cm.

The purpose of this study is to describe the percentage of cases that were able to get union, infection control and hypertrophy of fibula after its close transport through the olive wires of Ilizarov in massive loss of sequestered bone segment due to chronic osteomyelitis of tibia. We also noted the following: the length of tibia bone loss replaced by fibula; the mobilization status in terms of time using walking assist and the start of full weight bearing; postoperative range of motion of ankle and knee; additional procedures and possible complications in terms of re-fracture, infection, nonunion, pain, etc. We excluded patients with compromised blood supply of the limb or neurological loss.

Approval for this study taken from the hospital ethical committee.

Preoperatively written informed consent, detailed history, examination, and investigations including radiographs of tibia, with knee and ankle of the involved side (both AP and lateral views), taken. The preoperative range of motion of the knee and ankle were also recorded.

The surgery was performed in three stages. In the first stage, excision of all sequestered dead bone was performed and a pre-assembled Ilizarov frame without traction apparatus was applied. If periosteum was available, it was close, similar to an empty sleeve. The drain was removed after two days. The patient was kept on intravenous antibiotics based on culture and sensitivity. Patients were sent home and regular follow-up visits were arranged every two weeks. The second stage was decided when there was no frank pus from the wound or discharging sinus. In the second stage, usually after six weeks, an Ilizarov traction apparatus with olive wires, after proximal and distal fibular osteotomies, was applied. The osteotomies depended on the length of the segment required. Five days after the operation, fibular transport was started at the rate of 1 mm per day. It takes a week or two for complete fibular transport to the tibial defect. Once the fibula reached the target position, in the third stage, freshening of proximal and distal docking site of fibula was performed and fibula held there with one or two k wires. K wires were removed after 8 weeks. Once consolidation was complete, Ilizarov was removed, and a Patellar tendon bearing brace was applied. All of the surgeries were performed by the same team of surgeons (Figures 1 and 2).



Figure 1: Figure 1: 9 years old child presented with 7 months old history of road traffic accident. The patient was initially managed by bone setters. On presentation, the patient had discharging sinuses and non weight bearing. Figure 2: Immediate postoperative radiographs. Figure 3: Fibular transport assembly. Figure 4: Radiographs after 47 days. Figure 5: Radiographs after 8 months.

Results

The demographic data, steps of surgery, and outcome of surgical procedures are summarized in [Tables 1 and 2](#).

Hypertrophy of the transported fibula accompanied by full weight bearing and satisfactory joint motion occurred in all patients. The range of motions at both knee and ankle joints of each patient was measured using a goniometer ([Table 2](#)). There was a minimum follow up of two years.

Removal of the sequestered bone resulted in control of infection in all patients, and the second stage of surgery was performed after 27.17 ± 7.76 .

Fibular transport to tibia was successful in all patients. This transport took 16.58 ± 4.14 days to transfer fibula to the tibia defect. Docking site freshening and k wire fixation was done in all patients.

The length of tibia bone loss replace by fibula was 9.50 ± 2.23 cm. Union at both docking site occurred in all patients and grafting was not done in any patient. The mean days required for union after the freshening of docking site was 76.58 ± 6.20 .

All patients were kept non weight bearing during transfer of fibula, partial weight bearing after the freshening of docking site and full weight bearing three weeks after freshening of docking site. After removal of Ilizarov, full

weight bearing was allowed only with patellar tendon bearing brace.

The mean times of Ilizarov removal were 162.43 ± 15.15 days. The mean days required to start full weight bearing after removal of Ilizarov without PTB brace was 210.67 ± 15.57 . This was decided by the surgeon on the basis of hypertrophy of fibula.

Leg length discrepancy before surgery was 1.38 ± 0.90 cm and after surgery was 0.37 ± 0.52 cm. The maximum width achieved in mm on radiograph was 3.28 ± 0.75 . We saw pin site infection in 3 out of 7 patients but none of them was fulminant enough for change of wire, and all responded well to local pin site care.

One patient suffered supra condylar fracture femur while removing the Ilizarov; she was kept in an above-knee cast for 6 weeks before applying the PTB brace. The same patient had a fall 3 months after this event and suffered a fracture at the proximal docking site; it was treated again by an above-knee cast for 6 weeks. She is now full weight bearing with PTB brace.

Discussion

Segmental tibial defects due to any cause are rare in children and represent a challenging problem.^{12,14} There



Figure 2: 12 years old male presented to us after 4 weeks of road traffic accident. The patient was initially managed elsewhere with external fixation and wound wash. The Figure 6 shows immediately picture after the patient presentation. Figure 7 shows image after wound debridement. Figure 8 shows the excision of dead bone after 4 months. Figure 9 shows the fibular transport after 2 months. The Figure 10 is radiograph after 8 months and last Figure 11 shows patient picture who have smile on the face and fully satisfied with the treatment.

are multiple etiologies for this condition, such as severe trauma, osteomyelitis, reconstruction or congenital aetiologies, such as agensis or pseudarthrosis of the tibia.⁶ Management varies from amputation to various limb salvage procedures.

Tibialization of the fibula was first described by Albert in 1877. This researcher obtained fusion between the fibula and femur in a patient with congenital absence of the proximal tibia.¹⁵ Since then, the procedure has been employed successfully in many limb-salvaging operations. Huntington in 1944 popularized Huntington's procedure for treatment of tibial defects in children, which he described as a two-stage procedure.¹²

The Ilizarov method has been used successfully to transport bone and soft tissues longitudinally to treat tibial bone loss and, at times, to close an accompanying soft tissue defect.¹¹ The basic principles of the Ilizarov technique are stable fixation, preservation of blood supply to the bone segment, preservation of the osteogenic tissue of bone, early mobilization and avoidance of joint stiffness.¹⁶ The fibula has very rich vascular soft tissue coverage and can be used as a graft to cover the tibial gap.¹⁷

In 1971–1974, Zahiri et al., specifically used fibula in children for chronic osteomyelitis for the first time. The mean healing time was 18 months, which was much higher than that in our study. The main difference was that they used pop casts, instead of the Ilizarov, which were changed time to time. Moreover, the leg length discrepancy was also much higher than in our study.¹⁸

In 1996, Date et al. used a similar technique on 16 patients of all age groups. The average union time was 4.62 months. Excellent results were shown in nine patients, moderate in six and no hypertrophy in one patient. The main complications were delayed union and slipping of the fibular strut. The use of Ilizarov technique reduces the slipping of fibular strut.¹⁹

Similarly, MN Rasool used the ipsilateral fibular transport in chronic osteomyelitis of tibia in children without using the Ilizarov technique, but they used k-wires for keeping the fibula in position for a defect more than 8 cm, and plaster casts. For defects between 2 and 8 cm they used iliac crest bi-cortical grafts threaded over a Kirschner wire. And for defects less than 2 cm, they used cancellous chips. All children with greater than 2 cm shortening were kept immobilized. The healing time was 3.5–6 months. Shortening of limb was observed in the range of 1–20 cm (avg. 4 cm).²⁰

In his study in 2006, Levin proposed that among all the available methods for bony defects, vascularized bone transfer is particularly useful in large defects (>6 cm) and in cases in which osteomyelitis and unstable soft-tissue or beds make conventional techniques difficult.²¹

Wang X²² et al. conducted a study on 67 patients with tibial osteomyelitis using vascularized fibular grafts, with or without skin flap. The union time in their study was 4–6 months. However, in our study the union time was shorter than their study. They had two patients with secondary fractures of the fibula, while in our study not a single patient had such a complication.

Table 1: Demographic data and different steps of surgery.

Patients serial number	Gender	Age	Control of infection (days)	Days to achieve fibular transport	Length of fibula transported (cm)	Hypertrophy of fibula (mm)	Time to achieve union (days)	PWB with PTB (days)	FWB With brace (days)
1	M	12	27	13	10.0	3.1	68	28	42
2	M	4	25	20	6.0	1.9	73	31	51
3	M	11	35	14	11.0	2.8	75	26	59
4	M	10	15	20	12.0	3.9	84	40	61
5	F	10	34	26	8.0	4.1	79	33	49
6	M	10	35	19	9.0	3.3	71	37	43
7	F	5	31	14	5.0	2.0	87	48	51
8	F	7	23	14	12.0	4.0	69	49	50
9	M	6	21	13	11.0	3.0	74	40	51
10	F	8	25	19	10.0	3.7	75	42	49
11	F	6	39	14	9.0	3.6	80	39	60
12	M	10	16	13	11.0	4.0	84	48	59
Mean ± SD		8.25 ± 2.59	27.17 ± 7.76	16.58 ± 4.14	9.50 ± 2.23	3.28 ± .75	76.58 ± 6.20	39.42 ± 8.32	52.08 ± 6.39

Table 2: Outcome of surgery.

Patient serial number	Time to achieve full weight bearing without brace (days)	Range of motion of knee (degrees)	Range of motion of ankle (degrees)	Follow up complications	Limb length discrepancy before surgery (cm)	Limb length discrepancy after surgery (cm)
1	176	112.0	20.0	Nil	2.0	1.0
2	200	100.0	28.0	Nil	1.0	0.0
3	209	95.0	15.0	Nil	0.5	0.25
4	220	100.0	29.0	One pin infection	1.0	0.0
5	221	115.0	25.0	One pin injection	0.75	0.0
6	205	110.0	20.0	Nil	3.0	1.5
7	231	96.0	22.0	Nil	1.0	0.0
8	205	100.0	21.0	Nil	2.0	0.5
9	199	110.0	25.0	Supracondylar fracture of femur	0.75	0.25
10	210	90.0	18.0	One pin site infection	0.5	0.0
11	232	100.0	15.0	Nil	3.0	1.0
12	220	110.0	20.0	Nil	1.0	0.0
Mean ± SD	210.67 ± 15.57	103.17 ± 7.92	21.50 ± 4.54		1.38 ± .90	.37 ± .52

DeCoster²³, in his early study, noted that vascularized bone transfer has been suggested as the leading option for defects of 5–12 cm, but hypertrophy of the graft is unreliable and late fracture common, but we achieved hypertrophy of graft at all patients and no fracture even with a follow up period of 2 years.

The Ilizarov technique with ipsilateral fibular transport has multiple advantages. The only disadvantage of this technique is the long duration of treatment and that it needs an intact fibula.

Conclusion

These findings indicate that the Ilizarov frame with ipsilateral fibular gradual transport is a reasonable alternative for limb salvage in children with pan osteomyelitis leading to segmental tibial bone loss. Moreover, it is a cost-effective technique that can be successfully performed without expensive instruments. The hypertrophy of the fibula occurred in all children and superficial pin tract

infections were the most common complication noted. The Ilizarov method also offers a way of reconstructing large bone defects without a prohibitive risk of complications and thus offers an attractive route to limb salvage in place of amputation.

Authors' contribution

AUZ: Conception and design, Drafting of Manuscript. SJ: Conception of idea. Acquisition of data. AA: Data analysis and interpretation. AA: Data analysis & critical revision. All the authors have contributed substantially to the conception or design of the work or the acquisition, analysis, or interpretation of data for the work, drafted the work or revised it critically for important intellectual content, given final approval of the version to be published, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Conflict of interest

The authors have no conflict of interest to declare.

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