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Реконструкция диафизарных дефектов большеберцовых костей по методу Г.А. Илизарова

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Reconstruction of bone loss of diaphyseal tibial bones using G.A. Ilizarov technique

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Лечение сегментарных дефектов диафиза длинных костей является одной из сложнейших проблем, с которой сталкивается хирург в своей практике. К методикам, которые используются для перекрытия костных дефектов, относятся костная аутотрансплантация [1], заднебоковая костная трансплантация [2], аллотрансплантация [3] и тибиализация [4]. При применении всех вышеупомянутых традиционных методов лечения костных дефектов иногда требуется выполнение многочисленных оперативных вмешательств. Период лечения длительный, нагрузка на конечность может оказаться невозможной, а функциональные результаты часто бывают неудовлетворительными. Последние исследования продемонстрировали, что используемая методика Г.А. Илизарова является более популярной, нежели применение васкуляризированных костных трансплантатов, особенно при больших костных дефектах [5, 14].
Ключевые слова: большеберцовая кость, открытые переломы, остеомиелит, врожденный псевдоартроз, диафизарные дефекты, метод Илизарова.

The management of segmental defects within the diaphysis of long bones is one of the most challenging problems that the surgeon confronts in his practice. The procedures traditionally used to bridge bone gaps include autogenous bone grafting [1], posterolateral bone grafting [2], transplantation of allograft bone [3] and fibular protibia procedures [4]. All the above traditional methods of management of bone defects sometimes require multiple surgical interventions. The treatment period is long and weight bearing may not be possible while the functional results are often less than satisfactory. Recent studies showed that the G.A. Ilizarov Technique is a more popular than vascularised bone grafts especially for big bone defects [5, 14].
Keywords: tibia, open fractures, osteomyelitis, congenital pseudoarthrosis, diaphyseal defects, Ilizarov method.

THE ILIZAROV TECHNIQUE

The Ilizarov circular external fixator was designed in early 1950s [6]. It is a modular device allowing controlled mechanical forces (compression and distraction) to be applied at a pathological bone site. The system uses thin wires that are placed in different planes and are secured to modular rings under tension. These thin wires act as a small spring within a more rigid system of rings and concerning rods.

In this way the system provides stability against angular, rotational and transitional displacements, while it is relatively flexible in axial direction, allowing controlled axial loads to be applied at the zone of osteogenesis7. Mccoy, Chao and Kashman8 have compared the mechanical properties of four different external devices. They demonstrated that the Ilizarov external fixator had the lowest overall stiffness but high resistance to bending and rotation strains. It provides a dynamic osteosynthesis system, which prevents harmful (bending, translational and rotational) forces and allows only the useful (axial) forces to act at the osteogenesis site. This probably stimulates bone regeneration. In addition, Ilizarov apparatus allows multiplanar and multidirectional correction of deformities9. G.A. Ilizarov using his apparatus, developed new methods for salvage and reconstruction of a variety of serious congenital and acquired orthopaedic problems such as clubfoot, radial club hand, hand and leg length discrepancies, infected and non-infected non-unions, mal-unions, segmental bone defects, chronic osteomyelitis and joint contractures.

BIOLOGY OF OSTEOGENESIS BY ILIZAROV TECHNIQUE

The Ilizarov methods basically consist of application of mechanical forces to induce new bone formation (osteogenesis) by changing the mechanical environment at a pathological bony site. Distraction osteogenesis is the method of lengthening a long bone without grafting. After a diaphyseal corticotomy, the early mesenchymal in growth (early callus), is elongated by gradual, progressive distraction using a dynamic external fixator9. Corticotomy is a low energy osteotomy in which only the cortex is being cut. In this way the endosteum within the medullar canal, along with the medullary vessels is preserved. Gradual distraction of the corticotomy site organizes the early callus into a cylinder of parallel collagen fibers. The fibers are generally oriented longitudinally parallel to the tensile force, joining the distracted corticotomy surfaces and filling the gap created by distraction. Gradually as the distraction proceeds these fibers begin to ossify. As long as distraction is continuing a central region (the interzone), consisting histologically of undifferentiated cells, it does not undergo ossification, allowing for the lengthening to continue. Ossification is carried out from both corticotomy surfaces towards the central interzone and extends through the entire cross section of the newly formed tissue. When the desired lengthening is obtained the distraction is stopped and the interzone ossifies. Later, under the compression forces, applied by muscle contraction and weight loading the newly formed cylinder of solid bone remodels into cortex and medullary canal. The remodeling process may require years to produce mature lamellar cortical bone. Osteogenesis may be achieved by changing the mechanical environment to stimulate a pathologic bony interface (e.g. non-union) and restore bony continuity. By this technique variations of compression and distraction forces across a non-union or a pseudoarithrotic site are applied to induce osteogenesis.

The sequence of compression-distraction depends on the rigidity and compression of the pathologic bony interface. There are many critical factors related to osteogenesis. The local blood supply and the integrity of the periosteum are of great importance. Ilizarov emphasized the importance of careful corticotomy to prevent damage to the periosteum and to the medullar vessels. Recent experimental as well as clinical studies, however, have demonstrated that dissection of the nutrient vessels during the corticotomy, plays no significant role because the local vascularity is rapidly restored. The integrity of the periosteum is the most important factor for new bone formation.

Another factor promoting the bone formation is the stable fixation of the bone fragments, so that the forces applied at the osteogenic zone are controlled both in their magnitude and their orientation. Another critical mechanical factor is the rate and the rhythm of distraction. Ilizarov found experimentally, that distraction at the rate of 0.25 mm every 6 hours (1mm/day) is ideal. Distraction at a faster rate causes local ischaemia and subsequently retardation of poor-quality osteogenesis of the newly formed bone [9, 10, 11, 12]. Distraction at a slower rate will cause premature consolidation of the interzone, preventing further distraction. The last important factor is the level of the corticotomy11. It seems that the ideal place for the corticotomy is that at the metaphyseal region. Metaphyseal corticotomy must be preferred whenever possible. Weight bearing is considered to be essential both for bone regeneration and consolidation. We used the above biological processes of distraction in our practice.

MATERIALS

For the last 23 years (1990-2013) in different hospitals, 117 cases of tibial diaphyseal defects were operated on by the Ilizarov method. Male predominated with an average age of 35 years.

The age of the patients ranged between 12-58 years (average 35). The main etiology was open fractures as presented in Table 2.

Thirteen patients had active infections with drainage and seven ones were previously infected. The majority of the patients had undergone several previous operations including compression plating, external fixation, bone grafting and plastic operations. Many patients had shortening and angular or rotational deformities. The average duration of the bone defects was 10 months. After resection of the infected and necrotic bone the intercalate defect was 4.8 cm in average (range 3.5-8.5 cm).

Table 1

Male (83.76 %)	98
Female (16.24 %)	19

Table 2

Etiology

* Open fractures	46 cases
* Complications of surgically treated fractures	36 cases
* Osteomyelitis	22 cases
* Congenital pseudoarthrosis	13 cases
Total =	117 cases

METHODS

Proximal corticotomy and gradual transportation of a bony fragment towards the fragment opposite to the segmental defect (the target zone) was performed. Using the Ilizarov device the bone fragments, proximal and distal to the intercalate defect, were fixed in good alignment. A bone fragment of adequate length was then created after the corticotomy. Seven (7) to 10 days after corticotomy, the bony fragment was gradually transported axially across the defect. The transporting central ring connected to the bone fragment with two or more wires. As the bone segment was transported, a new gap was created behind it, while the length of the original gap was gradually reduced and finally, when the leading edge of the transported bone reached the bone surface opposite the segmental defect, it was closed. The new gap, created behind the transported bone, was regenerated by distraction osteogenesis. At the target zone variations of compression distraction forces were applied to induce osteogenesis. When the local circumstances allowed, two bone fragments, one proximally and one distally to the defect, were transported towards the filling of the gap was accelerated.

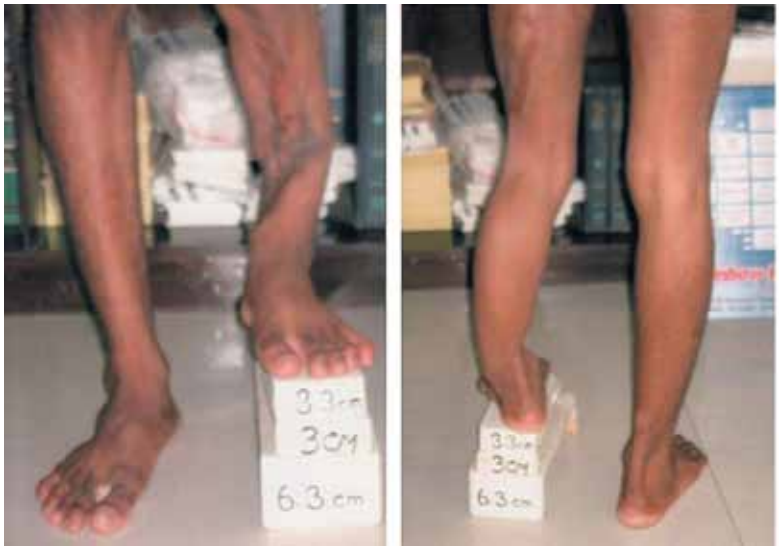

Fig. 1-2: Posterolateral bowing of left leg with 12.6 cm LLD

Fig. 3: Clinical photograph of 14 years old boy before surgery

Fig. 4: Radiograph of hypertrophic deformed fibula with gap non-union of left tibia, before surgery

Fig. 5: Radiographic result of distraction osteogenesis with correction of deformity is seen

Fig. 6: Patient with the Ilizarov apparatus after 8 months follow-up

Fig. 7-8: Clinical appearance of the patient after 14 months. No LLD, No deformity

Fig. 9: Radiographic result of tibia fibula

RESULTS

Regeneration of the distraction gap was achieved in all 117 patients. Union at the target zone was achieved in 116 patients out of 117 cases, and the union was not related to the length of the bony defect. In one patient there was a failure of union at the target zone. This was due to incomplete removal of the eburnated and atrophic bones. Healing of the infection occurred in all patients without a second operation. Residual varus deformity remained in two patients with 10 and 12 degrees of the deformity, respectively.

COMPLICATIONS

Pain at the site of the wires was a frequent problem during transportation of the intercalate segment. The most common complication was pin track infection, and it was treated by local care, and in 2 cases it was necessary to replace the wires. There was no incidence of pin track osteomyelitis. Edema of the leg and foot was always present during bone transportation. Joint stiffness of the knee and ankle occurred very often during bone transportation, but after the removal of the fixator the rehabilitation of these joints resulted in the full recovery of joint motion. There was no incidence of neurovascular complications. Psychological intolerance was seen in one young patient who required moral support until the end of the treatment.

DISCUSSION

Ilizarov method for the treatment of pseudoarthrosis and segmental bone defects has many advantages [10, 13, 14]. But several technical problems may arise if the details of the technique are not followed precisely. Very important thing is to excise all the infected and necrotic tissues. The inexperienced surgeons usually fail to carry out a sufficient radical debridement. With the current experimental and clinical experience it is evident that regeneration of bone at the site of distraction can be obtained safely. It was evident in our cases that wide debridement accelerated healing and helped to control infection. For successful bone transportation, it is also important to maintain the bone ends in good and stable position. In order to provide firm stability and to avoid axial deviation during distraction, the assembly of fixator in our cases usually required one or two rings proximally, one in the intercalate segment and one or two – distally. Another important factor is to achieve good contact of the bones, when the transported fragment contacts the bone surface at the target zone (opposite the segmental defect). A partial contact in one of our cases was the cause of non-union. The importance of controlling precisely the movements of the transporting bone fragment has been emphasized by many authors [5, 6, 11, 12, 13].

CONCLUSION

The Ilizarov techniques for the treatment of segmental defects of diaphyseal long bones are effective and offer many advantages. One of the greater advantages of this technique is the possibility of simultaneous treatment of bone loss, infection, non-union, deformity and problems of the soft tissues. In our all cases complications were not severe and did not affect the results.

REFERENCES

1. Bari M.M. A color atlas of limb lengthening, surgical reconstruction and deformity correction by Ilizarov technique. 2013.
2. Green S.A., Dlabal T.A. The open bone graft for septic nonunion // Clin. Orthop. Relat. Res. 1983. No 180. P. 117-124.
3. Reckling F.W., Waters C.H. 3rd. Treatment of non-unions of fractures of the tibial diaphysis by posterolateral cortical cancellous bone-grafting // J. Bone Joint Surg. Am. 1980. Vol. 62, No 6. P. 936-941.
4. Mankin H.J., Doppelt S., Tomford W. Clinical experience with allograft implantation. The first ten years // Clin. Orthop. Relat. Res. 1983. No 174. P. 69-86.
5. Clinical classification of post traumatic tibial osteomyelitis. Current concept review / J.W. May, J.B. Jupiter, A.J. Weiland, H.S. Byrd // J. Bone Joint Surg. Am. 1989. Vol. 71, No 9. P. 1422-1428.
6. Alonso J.E., Regazzoni P. The use of the Ilizarov concept with the AO/ASIF tibular fixateur in the treatment of segmental defects // Orthop. Clin. North Am. 1990. Vol. 21, No 4. P. 655-665.
7. Ilizarov G.A. Basic principles of transosseous compression and distraction osteosynthesis // Ortop. Travmatol. Protez. 1971. Vol. 32, No 11. P. 7-15 [in Russian].
8. Effect of controlled axial micromovement on healing of tibial fractures / J. Kenwright, J.B. Richardson, A.E. Goodship, M. Evans, D.J. Kelly, A.J. Spriggins, J.H. Newman, S.J. Burrough, J.D. Harris, D.I. Rowley // Lancet. 1986. Vol. 2, No 8517. P. 1185-1187.
9. McCoy M.T., Chao E.Y., Kasman R.A. Comparison of mechanical performance in four types of external fixators // Clin. Orthop. Relat. Res. 1983. No 180. P. 23-33.
10. Paley D. Problems, obstacles, and complications of limb lengthening by the Ilizarov technique // Clin. Orthop. Relat. Res. 1990. No 250. P. 81-104.
11. Ilizarov treatment of tibial nonunions with bone loss / D. Paley, M.A. Catagni, F. Argnani, A. Villa, G.B. Benedetti, R. Cattaneo // Clin. Orthop. Relat. Res. 1989. No 241. P. 146-165.
12. Golyakhovsky V., Ferrara P.L., Frankel V.H. Operative manual of Ilizarov techniques. St. Louis: Mosby, 1993. 236 p.
13. Kalnberz V.K. Compression-distraction apparatus. Stress and rigid system. LNIITO, Riga, 1981.
14. Ilizarov G.A. The transosseous osteosysthesis. Theoretical and clinical aspects of the regeneration and growth of tissues. New York: Springer, 1992.

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