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## Elongation of Legs: Ilizarov Methods — Our Experience

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Мы используем метод Илизарова для удлинения нижних конечностей с 1984. В период с 1984 по 1994 год пролечен 521 пациент и выполнено 611 операций. Во всех случаях использовался только внешний фиксатор Илизарова. Были полностью соблюдены основные принципы метода Илизарова.

Ключевые слова: метод Илизарова, удлинение, дистракционный остеосинтез.

### ETIOLOGY

The most of the patients were children with chondrodystrophio, poliomyelitis, developmental disease etc. There were been used methods of monolocal and polylocal, monosegmental and polysegmental distraction osteosynthesis. We succeeded to realise elongation of one segment 15 cm. And of the whole leg — 28 cm. In our work we had no petty number of complications: joint contracture, superficial wire Infection, foreign body reaction to wires, secondary equinus contracture, possibly requiring Achilles tendon lengthening. We are pleased by our results up to now.

### GENERAL PRINCIPLES

Classification. Distraction osteosynthesis:

- polysegmental;
- monosegmental;
- monolocal;
- bi-polylocal.

Combinatory distraction / compression osteosynthesis.

### METHODS

Tactics of treatment: individual, depends on etiology, tissue condition and function of the adjacent joints.

Firmness affixation. Depends on:

- Diameter of a ring or a half-ring. Optimal diameter of the ring or the half-ring is the one, where the distance between the inside of the ring and all area of the skin is 2-2,5 cm.
- Distance of ring to the bone segment. Bone segment should take central position in the ring or in a half-ring.
- The degree of tension of Kirschner wires. Kirschner wires are Inserted with speed no more than 800 - 850 revolutions in a minute, with axial pressure on the wire of 2 - 2,5 kG. The drilling operation should be stopped routinely during the insertion process. The mechanical resistance of the wires can be increased for about 15 - 40% by putting the wires under tension. The final tension of the wires should be calibrated from 80 - 125 kG. The diameter of the wires. 1,2; 1,5; 1,8 and 2,0 mm are available. With taking into consideration anatomo - topographical relations,

the biggest firmness is attained with crossing the wires under 30 - 45 degrees.

- Angles relation in insertion of the wires: proximal metaphysis of the femur — 40 - 45 degrees (in sagittal plane i.e. angle open forward and backward); distal metaphysis of femur, proximal metaphysis of tibia (lower leg) and distal metaphysis of tibia (lower leg): 50 - 60 degrees (in frontal plane i.e. angle open laterally and medially).
- Additional wires: Through proximal metaphysis of the femur 2 - 4 cm lower than basic couple of wires, exclusively sagittal, from forward to backward (with stopper). Through other metaphysis: in frontal plane. Advisable with stopper. Distraction threaded rods.
- Basic rings, or the half-ring with the ring are connected with distraction threaded rods, exclusively parallel with the longitudinal axis of the bone and mutual.

Basic consideration: dosage elongation and simultaneous correction of possible deformation.

### INDICATIONS AND

### CONTRAINDICATIONS

Indications:

- In adults: (shortening) more than 2 cm.
- In children: if it is impossible to elongate with distraction epiphysiolysis (closed area of growth, deformity of epiphysis or diaphysis, etc.) Indications for elongation are any congenital or acquired shortening, regardless of the age of the disease and size of shortening.
- Principle rule: In first stage it should be elongated (femur).
- Elongation of tibia in first stage is indicated in: (i) presence of foot deformity; (ii) presence of metadiaphysis deformation.
- Always, first perform elongation to the segment with deformation which should be corrected.
- Pause between elongation of one and other segment, should not be less than 6 months.

Contraindication:

- Somatic and mental disease.

### PREOPERATIVE CARE

Psychological preparation. Physical preparation.



Specific physiotherapy:

- to improve the movement coordination;
- training for walk with compensated lining;
- training for walking with support.
- Patient's position on the operative table:
- operative table adapted for Ilizarov action;
- femur; support under the sacrum, living an empty space under femur (30 - 35 cm), supporting stand under knee, with possibility for movement of the knee; patient's position;
- light abduction of thigh (10 - 20 degrees);
- lower leg; support under knee and foot; living an empty space under lower leg for free manipulation with wires (20 cm), possibility for free movement of ankle.

Preparation of operative field. Anaesthesia.

ELONGATION OF FEMUR AT ONE LEVEL

— MONOLOCAL, MONOSEGMENTAL.

ELONGATION OF FEMUR WITHOUT DEFORMATION. ELONGATION OF FEMUR WITH DEFORMITY ON THE DISTAL END (VARUS - VALGUS)

Insertion of the Kirschner wires. Wires are inserted at angles same as the normal elongation, with distal Insertion perpendicular to the longitudinal axis of the bone. For varus deformity, the angle between the two rings is open laterally and for valgus deformity the angle is open medially.

Assembling of the ring and half-ring, always perpendicular to the longitudinal axis of the segment (bone). Making small hypercorrection when wires are inserted is obligatory, as well as assembling of the ring, for 10 - 15 degrees more than real deformity. Example — if deformity angle is 30 degrees hypercorrection angle should be at least 40 degrees.

Osteotomy (corticotomy, compactotomy). The same like the normal elongation, with the level at the point of maximal deformity.

Assembling of the apparatus. Distraction threaded rods must follow the curvature of the bone, create the angle identical with that of the bone. Threaded rods are connected with the hinges.

The level of the application of the hinges must be at the top of the maximal deformity (it is the same level for corticotomy). The rule is strict parallelism between the threaded rods mutually and the bone.

ELONGATION OF FEMUR WITH DEFORMITY ON THE PROXIMAL END (VARUS — VALGUS)

Insertion of the Kirschner wires: Under the same angle relation like the normal elongation of the femur, but in order to correct the deformity at the same time, the angle between proximal half-ring and the bone should be increased in varus deformity (over 110 degrees) and decreased in valgus deformity (under 90 degrees). Corresponding that angle relation, assembling of the proximal half-ring follows.

OSTEOTOMY (CORTICOTOMY, COMPACTOTOMY)

Specification of the osteotomy (corticotomy). The choice of plane and the level of osteotomy should neutralized action of the monojoint muscles, i.e. muscles whose action will lead to displacement of the bone fragments after osteotomy.

At elongation of the femur. It is desirable, for the muscles that are acting to the hip, to stay at the proximal fragment (especially adductors), muscles which are acting on the knee to stay at the distal fragment.

Consecutive: It is advisable to direct osteotomy from forward and above, to backward and down. The plane of the osteotomy should be in the middle of sagittal and frontal plane. At the lower leg: Just below the tuberositas tibiae. In this way forces which tends to produce varus of femur and antecurvature and valgus of tibia should be neutralized.

ELONGATION OF THE FEMUR AT TWO LEVELS

Indication: Great shortening of the femur. Condition: Good quality of the bone. Good function of the adjacent joint. Tempo of distraction:

- 2 mm a day i.e. 1 mm at each level;
- shortening of the time of distraction at half;
- various of stiffness and neurological lesions.

Technique of working: Additional pair of Kirschner wires are inserted in the middle third of femur, at diaphysis. One wire, which is inserted from forward to backward is obligated to be with stopper. Recommendation: use "diaphyseal wires" with bayonet top. Osteotomy should be made at distal and proximal metaphysis of the femur.

Successiveness:

- distal osteotomy;
- connecting of distal and middle ring;
- proximal osteotomy;
- connecting of proximal and middle ring.

ELONGATION OF LOWER LEG AT ONE LEVEL

— monolocal, monosegmental.

Maximum angle of crossing the wires: at proximal ring 80 degrees, at distal ring 90 degrees.

To prevent complications (antecurvature and valgus during elongation) proximal ring should be assembled at angle of 100 - 110 degrees open medially and forward.

One of distal wire makes tibiofibular transfixation, to prevent normal anatomical relation in ankle.

One additional wire is inserted 2 - 3 cm below the proximal ring, and the other additional wire is inserted 2 - 3 cm above distal ring.

When the wire is passing through the anterior half of lower leg, distal, foot should be in maximal plantar flexion, when it is passing



through the posterior half, foot should be in dorsiflexion. Assembling the rings:

- Assembling the proximal ring: to prevent antecurvation and valgus deformity. Hug should be placed under angle of 100 - 110 degrees to the longitudinal axis of the bone, open medially and forward. This type of assembling of the ring makes possible asymmetrical distraction during elongation, with more Intensive distraction at the posterolateral threaded rod.
- Distal ring is assembled perpendicular to the longitudinal axis of the bone.

- Osteotomy (corticotomy, compactotomy):

Fibula: open or closed osteotomy of fibula at distal or middle third. Tibia: perpendicular or oblique corticotomy at the level of upper metaphysis. It is possible to make corticotomy at the diaphysis.

Lateral Incision of about 1 cm. Without division of muscles layers and without deperiosting.

Partial antero-lateral corticotomy with chisel. Rotational osteoclasia at the postero-medial surface of tibia. Check radiographs. Maximum distance (diastase) between fragments should not be more than 2 - 3 mm. AP and lateral radiographs are obligatory. Caution: danger of incomplete corticotomy. One or two sutures of the skin. Compressive bandage of the wound, which should be removed after 2 hours.

Assembling of the apparatus:

- Assembling of the threaded rods, solely parallel mutually and with the longitudinal axis of the bone.
- Assembling the hinges at the level of corticotomy. When performing corticotomy, hinges are loose and after finished corticotomy they should be fixed.

Warning: to prevent equinus or equinovalgus of the foot, during elongation, it is advisable (especially in greater elongation) to make subcutaneous, close, partial Achillotenotomy, or to fix the foot with 2 Kirschner wires, through calcaneus, fixed with half ring.

#### ELONGATION OF LOWER LEG AT TWO LEVELS

— bilateral distraction osteosynthesis.

Insertion of the Kirschner wires:

Distal metaphysis: Perpendicular of longitudinal axis of the bone (tibia). One of wires makes tibiofibular transfixation.

Proximal metaphysis: Insertion of the bundles of wires at angle open medially and forward in relation with the longitudinal axis of the tibia.

Middle third of lower leg: Two wires: one of them makes tibia-fibular transfixation, the angle between them to be no more than 60 degrees, angle with longitudinal axis of bone - perpendicular.

Transfixation of the foot it is advisable - to

avoid danger of stiffness of ankle. Assembling the rings: Distal: at angle perpendicular to the longitudinal axis of bone.

In the middle: at angle perpendicular to the longitudinal axis of bone. Proximal: at angle open forward and medially for about 10 - 15 degrees to the longitudinal axis of the bone.

Fixation of the foot with 2 wires, connected with half-ring.

Osteotomy. Fibula: two osteotomy: distal — between distal and middle rings, proximal — between proximal and middle rings. Tibia: two osteotomy: distal — between distal and middle rings, proximal — between proximal and middle rings.

Assembling the apparatus: Between middle and distal rings straight distraction threaded rods. Between middle and proximal rings: threaded rods, connected with langes. Advantage: Shortening the time of distraction for half (Elongation is performed at two levels per 1 mm a day at each level.

Attention:

- Risk of joint stiffness (flexion at the knee and equinovalgus at the foot). Prevention: transfixation of the calcaneus and/or partial Achillotenotomy.
- Risk of neurological lesions. Prevention: dosaged distraction and every day neurological assessment.

#### AFTER CARE

Immediate postoperative period (1 - 5 postoperative day): Check radiographs. Second postoperative day, sterile bandage. Standing and walking: first postoperative day.

Period of distraction: Distraction is started on the 5 - 6 postoperative day. Tempo of distraction: 0,25 - 2 mm / 24 hour depend of condition of distraction regenerate. Rhythm of distraction: usually 0,25 mm every 6 hour. That means a quarter of circle of threaded rod. Tempo is reducing in case of:

- poor quality of distraction regenerate;
- occurrence of neurological lesions;
- great pain;
- stiffness of joints.

Tempo of distraction is increased in case of creating abundant and dense regenerate. Checking the regenerate and the direction of the fragments:

- First radiographs — 10 day after operation.
- Next radiographs every 3 - 5 weeks.
- Intensive physiotherapy: 4 times a day for 1 hour.
- Sterile bandage. If there is no infection around wires, once a week. Weight bearing with support.

Tune (period) affixation: Fixation period starts with finishing the distraction. Periodical tightening of the apparatus (monomoment distraction of limb every 7-10 days) to prevent



lax of the apparatus, which is causing with local osteoporosis around wires. Check radiographs once a month.

Conditions for removing the apparatus:

- Free walk, without support with full weight bearing.
- Radiograph optical density of regenerate should be the same as the normal bone; continuity of cortical surface, the width of the regenerate to be the same as the normal bone. It is not necessary to wait for appearance of medullar canal.

To achieve faster compactisation of regenerate G. A. Ilizarov recommends method for "training of the regenerate":

- a necessary condition: unfragmented corticalis and disappearing of "growth zone" of

the regenerate.

- technically: gradual reducing of distraction forces with lax the apparatus for about 1 mm every 3-4 days, 4-5 times.
- alternative: laxing the apparatus 1-2 time a day for 0,25 mm, 7-10 days.

Period of full functional rehabilitation:

Starts with removing of the apparatus. It contains 2 periods:

- period of gradual raising of weight bearing, which continues 1,5 - 2 months (gradual release of support);
- period of full functional rehabilitation (active and passive movement of joints).

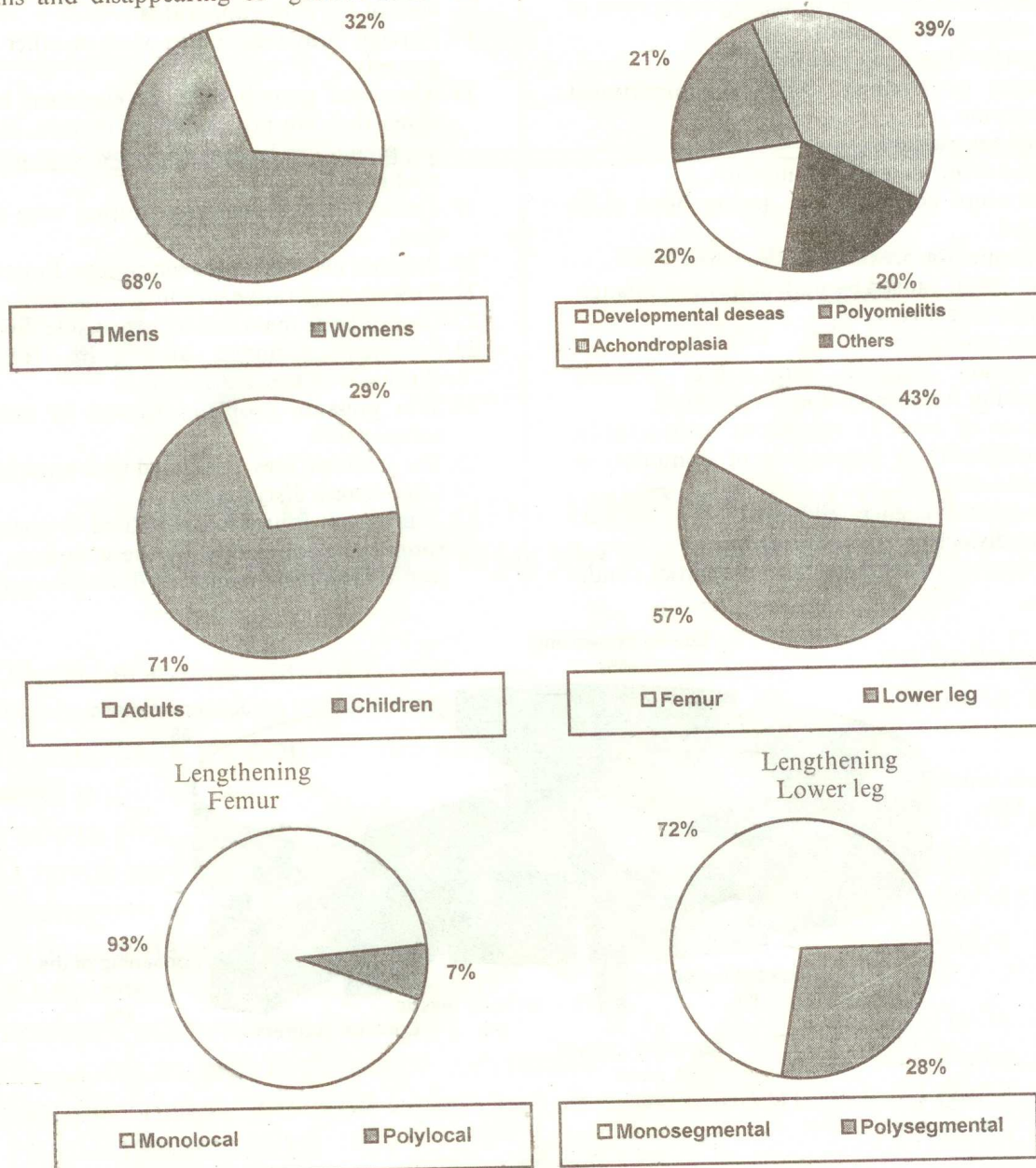


Fig. 1. Our materials.

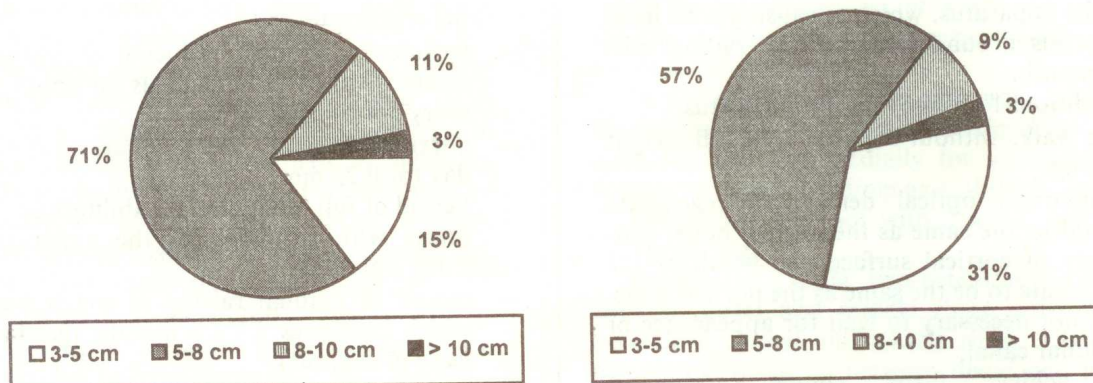


Fig. 1 (continued). Our materials.

### POSSIBLE ADVERSE EFFECTS

1. Damage to nerves or vessels caused during Insertion of the wires or during elongation of an anatomical segment.
2. Superficial or deep wire infection.
3. Edema or swelling, possible compartment syndrome.
4. Joint contracture.
5. Septic arthritis and osteomyelitis.
6. Premature consolidation during bone elongation.
7. Loosening or breakage of the wires.
8. Poor result caused by patient noncompliance.
9. Bone deformity.
10. Intractable pain.
11. Secondary equinus contracture, possibly requiring Achilles tendon lengthening.
12. Failure of bone to regenerate satisfactorily, development or persistence of nonunion or pseudoarthrosis.
13. Fracture of regenerated bone.
14. Joint dislocation or subluxation.
15. Persistence or recurrence of the initial condi-

- tion requiring treatment.
16. Necessity for reoperation to replace a component of the entire apparatus.
17. Foreign body reaction to wires or other components.
18. Abnormal growth plate development in patients that are not skeletally mature, including premature fusion, and slowed or accelerated growth.
19. Tissue necrosis occurring during wire insertion.
20. Pressure necrosis at the wire-tissue Junction
21. Excessive operative bleeding.
22. Loss of bone mass due to "stress shielding".
23. Persistent drainage after wire removal, chronic wire site osteomyelitis.
24. Skin pressure problems caused by external components.
25. The Intrinsic uses associated with anesthesia.
26. Limb length discrepancy.
27. Inadvertent Injury to the patient or operating room personnel caused by the wire (e.g., projectile wire from tip cutting during surgery).

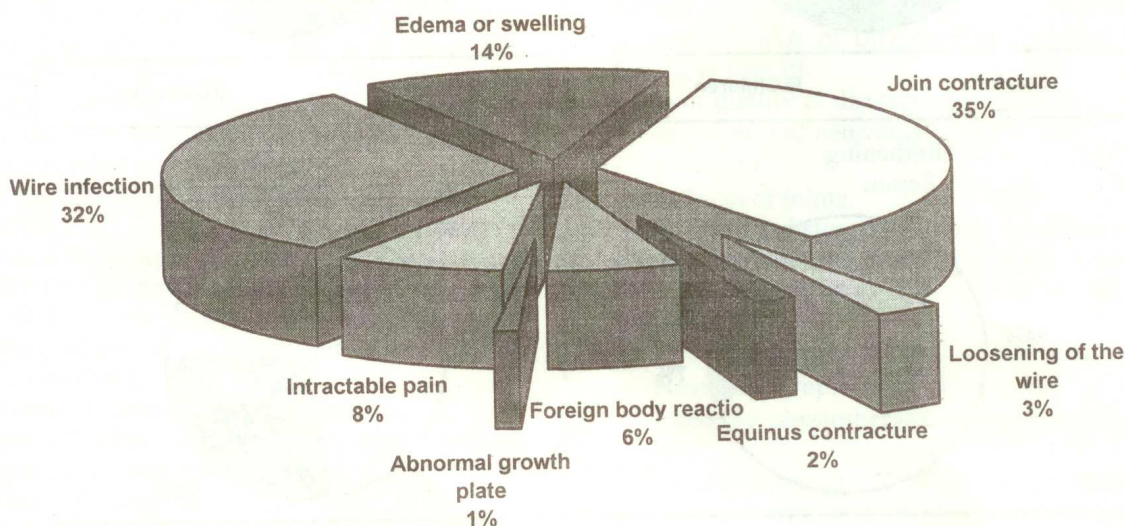


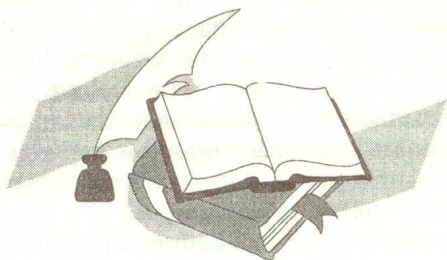
Fig. 2. Possible adverse effects.



REFERENCES

1. Илизаров Г. А. Возможности управления регенеративным и формообразовательным процессами в костной и мягких тканях // Проблемы чрескост. остеосинтеза в ортопедии и травматологии: закономерности регенерации и роста тканей под влиянием напряжения растяжения: Сб. науч. трудов КНИИЭКОТ. — Вып.8, Курган, 1982. — С. 5-8.
2. Илизаров Г. А. Значение комплекса оптимальных и биологических факторов в регенеративном процессе при чрескостном остеосинтезе // Эксперим.-теорет. и клин. аспекты разрабат. в КНИИЭКОТ метода чрескостного остеосинтеза: Тез. докл. Всесоюз. симпозиума с участием иностранных специалистов (Курган, 20-22 сентября 1983 г.). — Курган, 1983. — С.5-15.
3. Молекулярные аспекты активирующего влияния на остеогенез дистракционного остеосинтеза / Г. А. Илизаров, К. С. Десятниченко, Ю. П. Балдин, С. П. Изотова // Проблемы чрескостного остеосинтеза в ортопедии и травматологии: Закономерности регенерации и роста тканей под влиянием напряжения растяжения: Сб. науч. трудов КНИИЭКОТ. — Вып. 6. — Курган, 1982. — С. 105-112.
4. Фриденштейн А. Л. Стволовые остеогенные клетки костного мозга // Онтогенез. — 1991. — Т. 22, № 2. — С. 189-197.
5. Относительное содержание стволовых остеогенных клеток в костном мозге длинных трубчатых костей собак в процессе удлинения голени / Р. Л. Галанова, Л. А. Палиенко, П. Ф. Переслыцких, Ю. П. Балдин // Чрескостный компрессионный и дистракционный остеосинтез в травматологии и ортопедии: Сб. науч. работ КНИИЭКОТ. — Вып.3. — Курган, 1977. — С.54-57.
6. Особенности кроветворения при дистракционном остеосинтезе / Ю. П. Балдин, К. С. Десятниченко, С. П. Изотова, С. И. Ширалиева // Современные аспекты чрескостного остеосинтеза по Илизарову: Материалы науч. конф. — Казань, 1991. — С. 138-139.

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