4

K-Wire and Schanz Screw Application Techniques

Mehmet Çakmak and Melih Cıvan

4.1 Kirschner Wires

K-wires have two kinds.

4.1.1 Transfixation Wires

They are 1.5- and 1.8-mm-diameter wires. The hardness is proportional to the fourth power of diameter. Two-millimeter-diameter wires have also been put into use in recent years. The small 1.5-mm wire is used especially in pediatric and upper extremity cases. K-wires can be tipped trocar or bayonet (Fig. 4.1).

Thick diaphyseal cortex can be drilled without heating with the bayonet-tipped wires. Trocar-tipped wire is used in metaphyseal or epiphyseal region for cancellous bone.

Wires must be straight and perfect to use. Any deformed section can lead to failure after application of the wires.

After transfixation, wire passes through the bone, and one end of the wire must be connected to the fixator. The other end must be tensioned before fixation. While tensioning, caution must be exercised in terms of bending the frame. If the wire passes through the bone far from the frame, connection parts must be used for the fixation such as nuts, washers, and clamps. Otherwise, the imbalance of the system affects the soft tissue, which leads to pain and infection.

Transfixation wires can be reshaped as olive wires through twisting or rotating (Fig. 4.2).

4.1.2 Olive K-Wires

These wires have integrated sphere-shaped olives in the middle section that allow the stabilization or traction of the bone segments (Fig. 4.2). Their diameters are the same as transfixation wires. The purposes of these olive wires are:

(a) Suppression of bone movement on K-wires during deformity correction
(b) Form an anchor for the correction movements
(c) Use as a transfixation wire for traction of the bone segments or fragments (Fig. 4.3)

Before use, a small incision must be made with a no. 11 scalpel for the thick olive part to pass through the skin. The olive must withstand the cortex. For the stabilization purposes after the fixation of the stopped end to the ring, counterside must be tensioned before fixation. For traction of the bone fragments with the released stopped end, the counterside must be tensioned and fixated. Conical-shaped stopping wires are

---

M. Çakmak, Prof. MD (✉) • M. Cıvan, MD
Istanbul University, Istanbul Faculty of Medicine,
Orthopaedic and Traumatology Department,
34190 Istanbul, Turkey
e-mail: profcakmak@gmail.com;
melihcivan@gmail.com

M. Çakmak et al. (eds.), *Basic Techniques for Extremity Reconstruction*,
https://doi.org/10.1007/978-3-319-45675-1_4

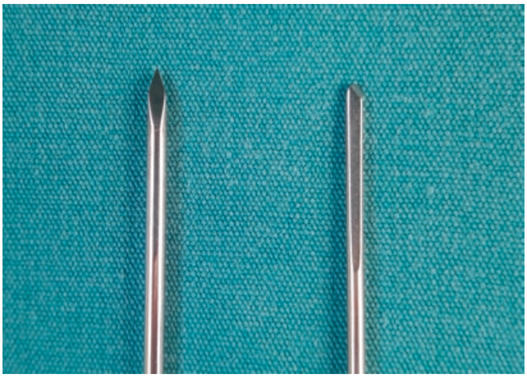

Fig. 4.1 Trocar (*left*) and bayonet-tipped (*right*) K-wires

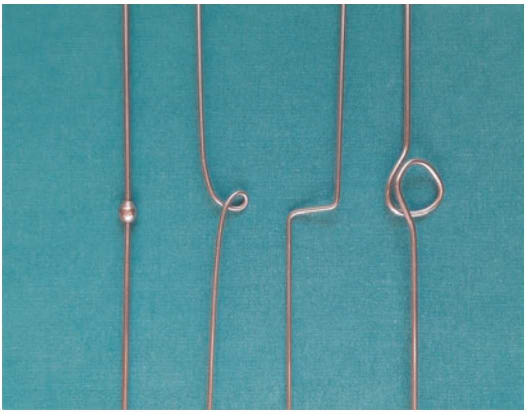

Fig. 4.2 Rotated or twisted K-wires can be used instead of olive K-wires

used for the same purposes. They can be used safely in osteoporotic bones because of the wide diameters.

4.2 Wire Tensioners

Standard wire tensioners were made from two telescoping metal tubes with a spring mechanism or threads (Fig. 4.3). The outer tube is consistent with the ring at the fixation point. Inner tube is used for straining the wire through rotation of the clamping lever. A tensioner with an automated spring mechanism that allows the determination of the tension magnitude has been introduced in recent years.

In the Ilizarov's circular external fixator system, mechanical factors such as the number of wires, tension, and distance between wires and frames are very important. The primary target is to obtain the maximum stability with the minimum number of wires and rings.

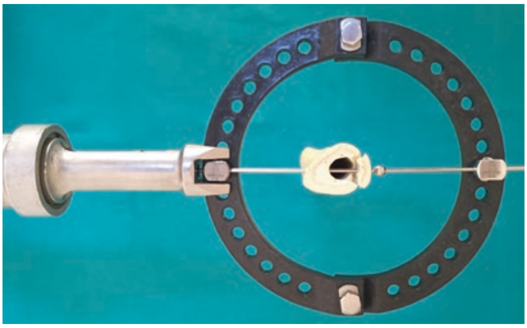

Fig. 4.3 Using the wire tensioner to apply traction to bone fragments

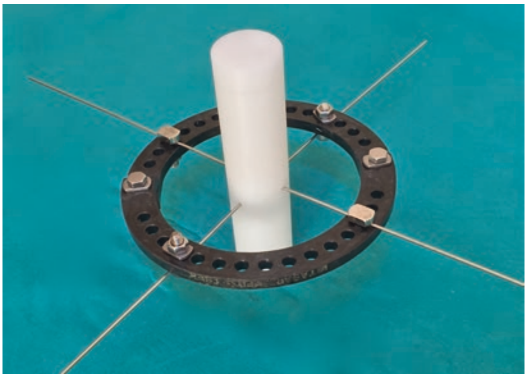

Fig. 4.4 Displaying a 90° angle with K-wires crossing under and over the ring

4.3 Application of the K-Wires

The number of wires and application positions must be considered for each patient within specific principles. To obtain maximum stability for each patient, two or more transfixation wires that cross each other at 60–90-degree angles must be used. While one of the wires must cross under the 5-mm ring, the other wire must cross over it (Fig. 4.4).

If stability is compromised because of limited angulation and pathologic movement occurs, additional oblique positioned wires can be applied.

Transfixation wires must be used while considering anatomy; otherwise, vascular and nerve damage may occur. Wire inlets and outlets should be 1.2–2 cm away from important vascular and nerve structures.

Wires of the main ring must cross at the metaphyseal region to protect periosteum and bone marrow. Also, the nutritional arteries should be protected.

Malpositioned transfixation wires can penetrate or push aside vascular or nerve structures. Massive bleeding at the entry or exit points of the wires refers to vascular injury, which requires vascular repair after the removal of the wire.

Intraoperative nerve damage detection is difficult. Fasciculation at the related muscles indicates nerve damage. Nerve function usually returns after removal of the wire.

Necrosis at the soft tissue is also an important consideration. Surrounding tissue destruction caused by crossing the wire, over-tension, and thermal tissue damage can lead to necrosis.

Before use, the perforator wires must be able to withstand the cortex perpendicularly without any rotational movement. Bone penetration must be as midline as possible.

K-wires sometimes bend while crossing the bone, which extends the passageway. In these situations, fixation stability compromises and soft tissue damage occurs. Risk for pin tract infections and loosening increases. The solution is in using an alcohol- or antiseptic solution-soaked gauze to hold the wire while using the perforator.

Hand perforators are more suitable for bone drilling. Electrical perforators have risk for thermal tissue damage, especially in the cortex. Thermal necrosis increases the resistance for drilling. When using an electrical perforator in bone tissue, it must be used in short intervals and at low speed. (hammer drilling). The wet gauze also facilitates cooling of the wire.

The drill must be stopped after the bone has been crossed because the rotating tip of the wire can cause soft tissue damage. Pliers can be used for nailing the wire for crossing the soft tissue.

If the wire is overheated or smoke can be seen coming from the bone, the wire must be changed for a cold one from a different passage.

For surfaces where subcutaneous tissue is thin such as the anteromedial tibial surface, wire must be positioned from the contralateral surface so as to reduce soft tissue damage.

When the fixator is completely applied, related joints must be evaluated for movement. Wires can limit movement because of the tension on the skin. In these situations, wires must be changed.

For maintaining joint movement and extremity function:

(a) Tendon penetrations must be avoided.
(b) Muscles must be at optimal functional length during K-wire applications.
(c) Synovium must be protected.

For example, in the distal femur while crossing the wire from the anterolateral to posteromedial, the quadriceps muscle must be perforated at 90 degrees of knee flexion, and the wire must be advanced perpendicularly to the femur. After the bone has been crossed, the knee must be fully extended before crossing from the other side (Fig. 4.5).

In cruris, while crossing the wire from the anterior compartment, the foot must be at plantar flexion. After the bone is crossed, for the peroneal muscles, the foot must be at inversion. When the triceps surae is being crossed, the foot must be at dorsiflexion position (Fig. 4.6). Use of correct positions for K-wire application is essential for joint movement.

Tendon perforations can be prevented using a simple method. First the whole tendon tracing must be palpated. After crossing the anterior soft tissue, the drill must be stopped. When the bone is not penetrated, if the related joint is maneuvered, the K-wires will also move at the same time. This means the wire has penetrated the tendon. If it is the entry point, it must be changed.

For using the Ilizarov's circular external fixator at the proximal femoral region, 4–6-mm-diameter threaded half-pins must be used for

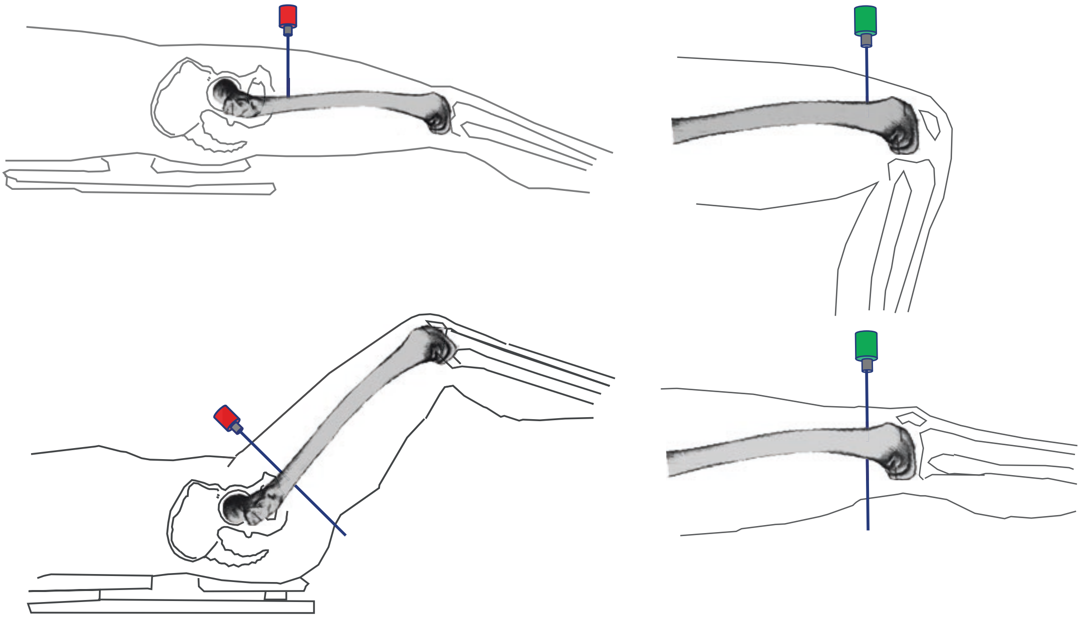

Fig. 4.5 Joint positions for applications of K-wires at the proximal and distal femur

safety (Fig. 4.7). Soft tissue damage and obstructions can be prevented with guides for these applications. Half-threaded pins must be used with T-handles after the bone is contacted to prevent thermal tissue damage. Before tapping the half-pins, the tract must be drilled.

Especially in specific locations, transfixation wires can thread vascular and nerve structures. Infection and thermal injury are other disadvantages. Nonetheless, the half-pins introduced by Cattaneo and Catagni are easy to use and safer than transfixation wires. However, the application of these half-pins contradicts the main idea and Ilizarov's doctrine of stability and elasticity; they are much safer, and some authors, along with our department, use half-pins instead of transfixation wires in these specific conditions.

4.3.1 Skin Positions

Skin positions are important in K-wire crossing because of the excessive and prolonged pain and pin tract infections. For example, while crossing a K-wire from anterior to posterior in the distal femur at knee 90° of flexion, anterior skin moves distally and posterior skin moves proximally. Transfixation of the anterior skin of the thigh at this position limits extension, which leads flexion contracture.

To prevent skin positioning problems and skin necrosis:

(a) During the limb lengthening, extensive skin tension in corticotomy site must be considered, and more skin tissue must be provided during transfixation. If compression is planned, skin must be pushed against the compression direction.
(b) While correcting angular deformities with open-wedge osteotomy, skin and subcutaneous tissue must be loose at the concave side, and more soft tissue must be provided.
(c) Entry and exit points of the wires must be positioned at sites that have limited skin movement during joint motion.

4.4 Tensioning of K-Wires

While circular external fixators provide maximum stability, K-wires spread the forces equally and obstruct bone movement. Without adequate tension and proper fixation, the small diameter of

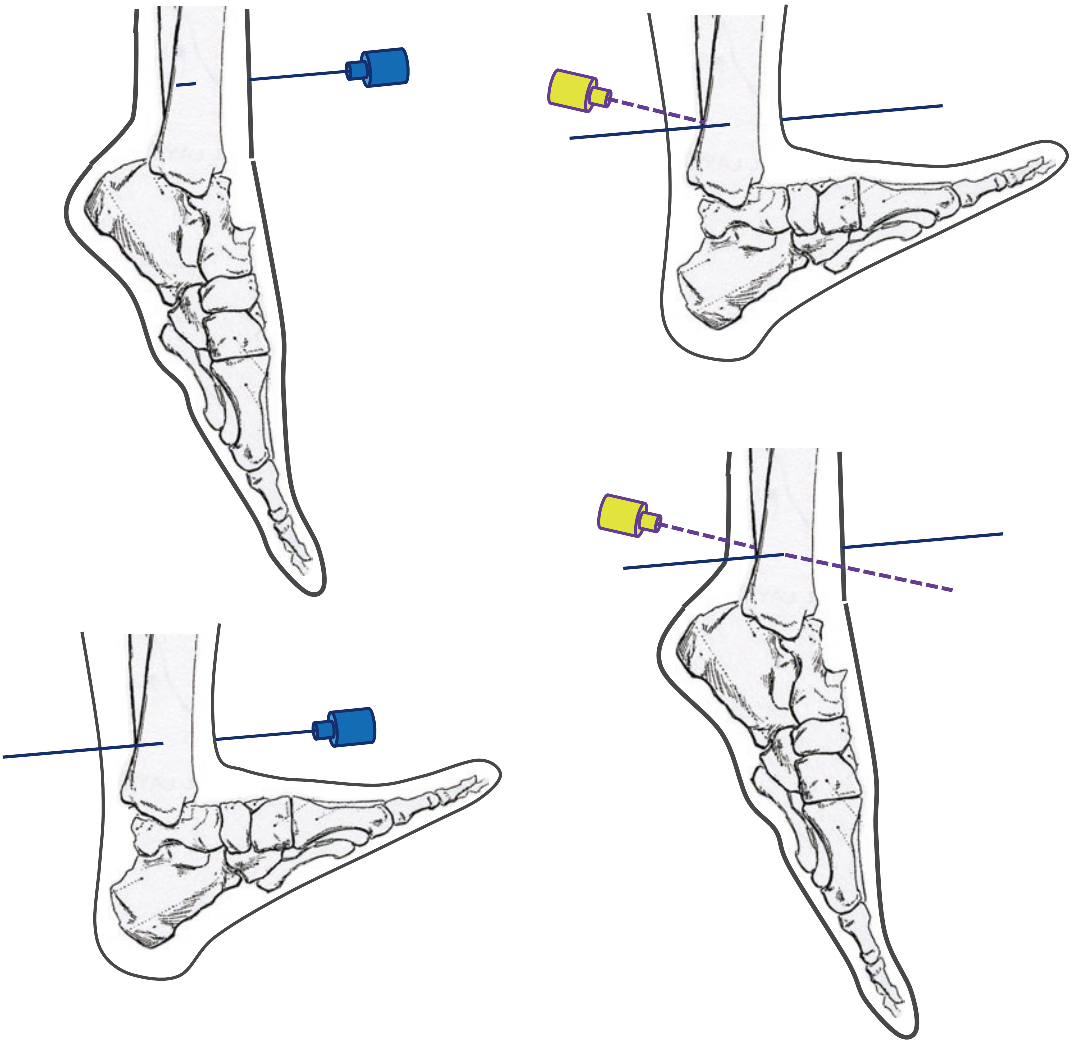

Fig. 4.6 K-wire application at the ankle region

the K-wires compromises the stability of long bones. For optimal stability and to overcome intrinsic tissue resistance, K-wires must be tensioned like tightrope. Cyclic micromovements on axial loading are acquired with the movement of the K-wires, like a springboard effect. If the wires are tensioned at optimal strength, the risk for bone and soft tissue damage reduces to a minimum. If the tension on wires is not enough, continuous vibration irritates the patient and increases the risk for infections. An improperly prepared Ilizarov's circular fixator device is a constant source of torment.

Wire tension is also an important factor on induction of osteogenesis. Too tight or loose wires inhibit osteogenesis. When half-pins are loaded from the non-crossed end, it moves but the stiffness remains the same. If transfixation wires take a centered load, it effects stiffness. More loading leads too greater stiffness on wires. When K-wires deviate by 4 mm, their stiffness reaches the half-pin level.

The main factor that reduces wire tension is minimal deviation at the wire fixation. Therefore, the adequate tightening of the nuts is important (20 Nm).

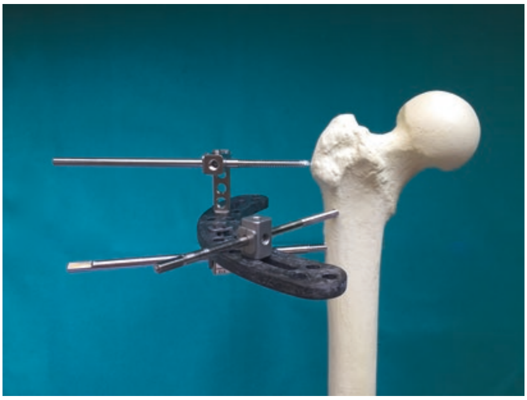

Fig. 4.7 Fixation at the proximal femoral region with threaded half-pins

Heat and the axial cyclic loading are non-controllable factors.

Larger rings at the wider areas of limbs improve forces for adequate wire tensions.

4.4.1 Recommended Wire Tensioning

Different amount of tensions for different situations are listed below (Table 4.1):

4.4.1.1 Transfixation Wire Tension

In some cases, the number of wires can be increased for more stability.

4.4.1.2 Olive Wire Tension

If the stop is at the counterside of the bone, optimal tension is 120 kg. If the stop is used for interfragmenter compression, optimal tension is 30 kg.

4.4.2 Wire Tensioning Techniques

4.4.2.1 Rotating the Bolts

If the bolts are rotated, wire tension increases. It is a simple technique that requires no devices. The disadvantage is the malpositioning of wires during rotation, which leads to tension in the soft tissue and pain.

Table 4.1 Recommended wire tension in different situations

Situation	Recommended wire tension
One wire with half ring or arch	50 kg
One wire with one whole ring	70 kg
Two wires with one whole ring (adolescent)	110 kg
Two wires with one whole ring (adult)	120 kg
Two wires with one whole ring (overweight patients)	130 kg

4.4.2.2 Inclination Technique

After fixation of the tip of the wire, the other end must be fixated with an obliquely positioned clamp. For maximum tension, bilateral clamps can be used.

4.4.2.3 Standard Tension Device

We use standard tension devices for adequate tension. Not knowing the amount of the tension is a disadvantage.

4.4.2.4 Dynamometric Tension Device

These parts are calibrated for use in range of 50–130-kg forces. Tension can be adjusted manually.

The wires must be cut until 4 mm is left from the ring and bent.

Bibliography

1. A.S.A.M.I Group. Chapter 7: Basic principles of operative technique. In: Maiocchi AB, Aronson J, editors. Operative principles of ilizarov; Milan, Medi Surgical, 1991. p. 65–71.
2. Aronson J. Proper wire tensioning techniques for ilizarov type external fixators. Tech Orthop. 1990;5(4):27–32.
3. Aronson J, Harp JH. Mechanical considerations in using tensioned wire in a transosseous external fixation systems. Clin Orthop. 1990;280:23–9.
4. Aronson J, Harrison B, Boyd CM, Cannon DJ, Lubansky HJ. Mechanical induction of osteogenesis: importance of pin rigidity. J Pediatr Orthop. 1988;8(4): 396–401.
5. Green SA. Components of the ilizarov system. Tech Orthop. 1990;5:1–11.
6. Green SA. The use of wires and pins. Tech Orthop. 1990;5:19–25.

7. Green SA, Harris NL, Wall DM, Ishanian J, Marinow M. The rancho mounting technique for the ılizarov method, a preliminery report. Clin Orthop. 1992;280: 104–16.
8. Ilizarov GA. Chapter 1: The apparatus : components and biomechanical principles of application. In: S.A G, editor. Transosseous osteosyntesis. Heidelberg: Springer; 1992. p. 63–136.
9. Maiocchi AB Chapter 2: Instruments and their use. In: Maiocchi AB, Aronson J, editors. Operative principles of Ilizarov; Milan, Medi Surgical, 1991. p. 9–32.