Method of Unified Designation of External Fixation (MUDEF)

4

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4.1 Introduction

External fixation for the treatment of orthopedic and trauma patients is a technically demanding procedure. Consequently, the type of transosseous element (K-wires, S-screws, half-pins), their levels and crossing positions, the levels of the external supports of the fixator, and the biomechanical relationship between the supports must be strictly controlled and standardized.

Text annotations, even those accompanied by explanatory figures, may be grossly inaccurate because they leave too much room for data interpretation. The three-dimensional image achieved using computer techniques is by far the most precise approach; however, the creation of such images to serve as models for all of the situations encountered in external fixation would be very expensive and laborious.

With the use of a minimal number of symbols, MUDEF of the long bones provides a comprehensive description of the type and spatial orientation of the transosseous elements, the order and direction of their crossing, and the form (geometry) and dimensions of the external supports, as well as the biomechanically indicated relationship between the supports. Additionally, MUDEF provides other advantages:

- *Study of the method of external fixation*: The use of MUDEF in instructional lectures, monographs, manuals, and original articles allows accurate recording of the entire algorithm of the operation and avoids failure of the method due to inaccuracy and to mistakes made during its implementation.
- *Elimination of pin-induced damage to neurovascular structures*: In Germany, Italy, the USA, and Russia, atlases have been published that provide schemes for the transverse sections of the extremities and designate the sectors where it is dangerous to pass K-wires and half-pins. The use of the coordinates in any of the atlases significantly facilitates definition of the dangerous sectors and safe corridors during the operation.
- *Facilitation of routine work* during the recording of external fixation operations to produce a record that is self-explanatory.
- *Improvement in the accuracy and comprehensiveness of remote consultations (including teleconsultations)*: MUDEF allows the recommended configuration of the external fixation device for a specific case to be sent and received, and adequate data exchange during online conferencing/consultations.
- *Simplified updating of the computer database*: The optimal configurations of external fixation devices in cases of different orthopedic and traumatological pathologies can readily be stored.
- *Estimating and detailing of complications*: For example, pin-tract infections are the most frequent complication in external fixation. MUDEF allows identification of the levels and positions at which pin-tract infection most often occurs. Similarly, the transosseous elements that cause pain and limit the range of motion of the joints can be identified.
- *Unification of scientific research on external fixation devices*: The most important characteristics of external fixation devices are: the option to change the spatial orientation of bone fragments (reduction); the rigidity of the fixation; the possibility to maintain extremity function. During the development of generally accepted criteria for each characteristic, the application of MUDEF allows the specific configurations of external fixation devices to be compared in order to select those that are optimal.
- *Increasing the accuracy in the description of a local area*: The locations of punctures, incisions, and drains can be defined.
- *Overcoming language barriers* and establishment of a *universal international code* for the description of external fixator constructions.

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Table 4.1 Standard and additional symbols used in MUDEF

Standard symbols	Additional symbols
1. Roman numerals from 0 to IX designate the *level* of the wire or half-pin insertion. 2. Arabic numerals from 1 to 12 designate the *position* of the wire or half-pin insertion. 3. A comma (,) is placed between symbols indicating level and position and between symbols indicating position and orientation of the half-pin insertion. 4. A dash (-) between symbols indicates the positions in the projection through which wire is passed. 5. A semicolon followed by a space (;) divides the groups of symbols defining the transosseous elements. 6. Numerals indicate the angle of half-pin insertion (in degrees). 7. Parentheses ( ) enclose the designation of transosseous elements passing through the radius or fibula.	8. For olive wire designation, the correspondent position is indicated in bold type. 9. Numerals define the insertion order of the transosseous elements. 10. A line drawn under the symbols of the transosseous elements shows that all of them are fixed to the common support. 11. A continuous line drawn under symbols of transosseous elements shows that they are fixed to a single, common support of the frame. 12. Symbols to designate the device type: mon. = monolateral bil. = bilateral sec. = sectorial sem. = semicircular cir. = circular hyb. = hybrid 13. Symbols are used to designate the support form; for example, 3/4 indicates a three-quarter circle (i.e., missing a 90° section); 1/2 indicates a semicircle, etc. 14. Numerals indicate the dimensions of the support (in mm); for example, the diameter of a circular support. 15. Symbols are used to specify the biomechanical relationship between the supports: 16. —; ←→; →←; —o—; ←o→

4.2 Symbols Used

The standard and additional symbols used in MUDEF are shown in Table 4.1. The additional symbols improve the comprehensiveness and quality of the information obtained with MUDEF, but they are not strictly obligatory.

4.3 Coordinates

For the long bones, MUDEF is based on a system of coordinates. With the help of these coordinates each segment of the extremity is divided vertically (into levels) and horizontally (into positions).

4.3.1 Levels

Vertically, each segment of the extremity is divided into eight basic and equally spaced levels designated by Roman numerals from I to VIII (Fig. 4.1). The device illustrated in Fig. 4.2 is used for the rapid designation of all or any one of the basic levels.

4.3.2 Positions

Each transverse section at each level is divided into 12 equal radiating sectors (similar to a clock-face); the sectors are accordingly defined by positions 1–12. The long axis of the bone is the center of division of each level into the 12 sectors (Figs. 4.3 and 4.4).

4.4 Designation of Transosseous Elements

In MUDEF of the forearm and lower leg, the symbols for the transosseous elements inserted through the radius and fibula, respectively, are enclosed in parentheses. Transosseous elements introduced between the levels (positions) are designated with the symbol of the level (the position) closest to which the transosseous elements are to be located. When a transosseous element is not inserted perpendicular to the longitudinal axis of a bone fragment, the thickness of the soft tissues must be taken into account during the planned insertion of the half-pin or wire at a reference level.

4.4.1 Designation of K-wires

For trans-segmental transosseous elements (e.g., K-wires, Steinmann rods, Kalnberz rods), it is necessary to designate two positions on opposite sides of the bone, for example 3 and 9, 6 and 12, 1 and 7 (Figs. 4.5 and 4.6). The annotation V,2-5 indicates that the K-wire is out of the bone. This system

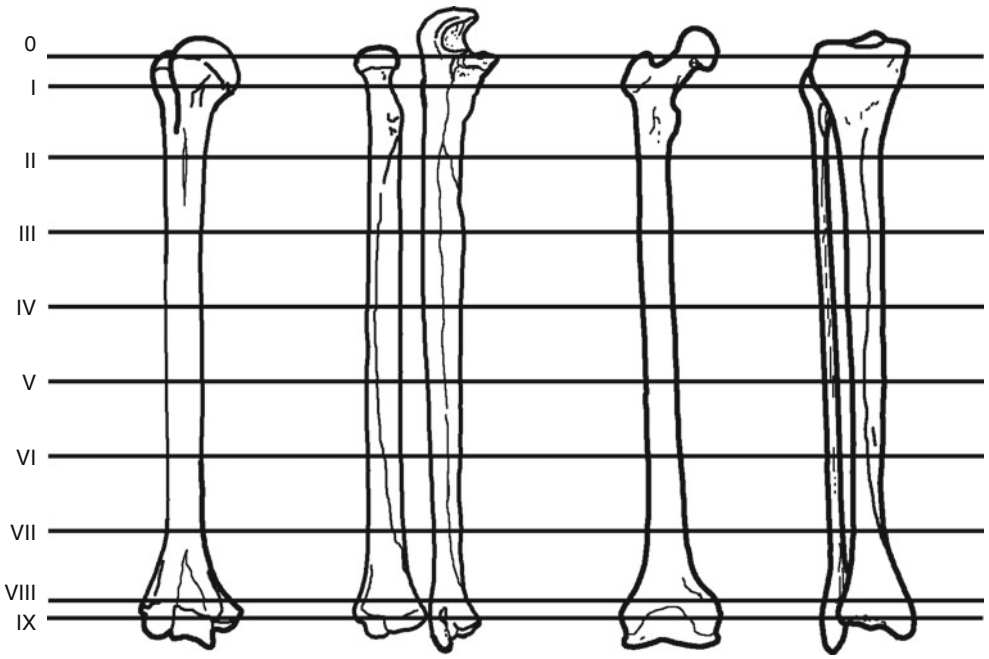


Fig. 4.1 Division of each segment into levels. Levels I and VIII are located in the metaphyses of the long bones, where the proximal and distal basic transosseous elements are passed in the majority of external fixation operations. Level I of the humerus is the level of the greater tuberculum (40 mm distal to the acromion), and level VIII is the level of the epicondylus lateralis. Level I of the forearm is at the level of the column of the radius (40–50 mm distal to the apex of the olecranon), and level VIII is 30 mm proximal to the apex of the styloid process of the radius. The most prominent lateral part of the greater trochanter is located at level I of the femur, and the epicondylus lateralis at level VIII. Level I of the lower leg is located at the tibial tuberosity, and level VIII at the distal tibiofibular syndesmoses. Levels 0 and IX are located at the proximal and distal epiphyses of the bones of each segment; they are rarely used in external fixation. The distances between levels 0 and I and between levels VIII and IX are less than the distance between the basic levels

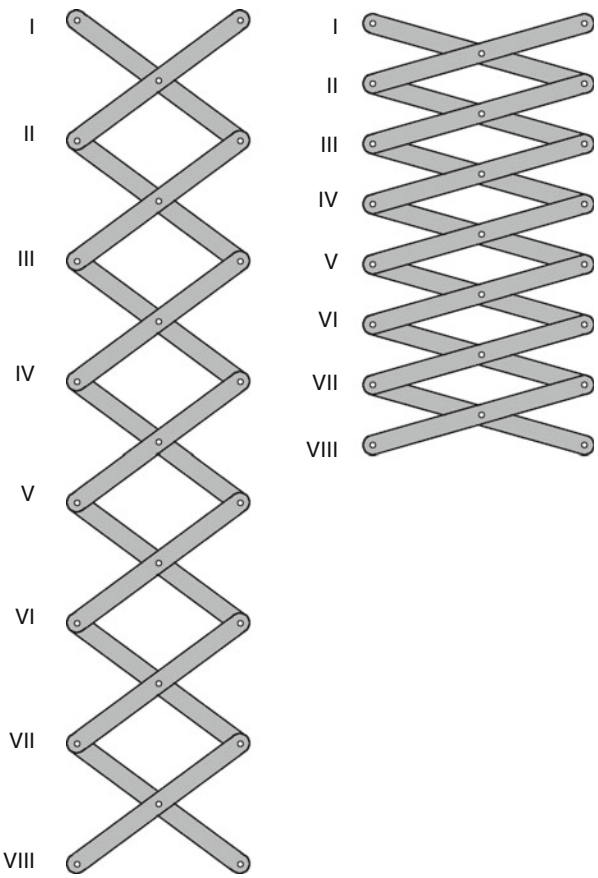


Fig. 4.2 This device is used for the rapid designation of all or any one of the basic levels. It consists of 14 jointed laths each measuring; 80×30 mm. The side joints of the device are at the projections of levels I and VIII, and the whole segment is equally divided to give the location of every level. An elastic tape marked with each of the eight levels can be used for the same purpose

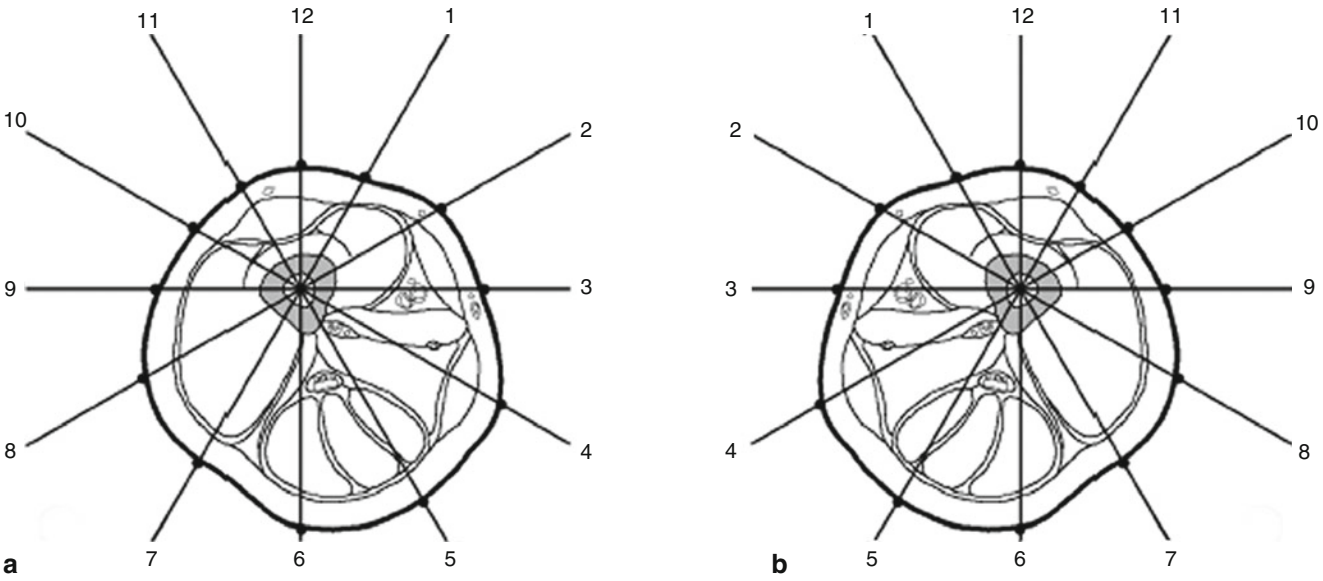


Fig. 4.3 Designation of positions at level IV on the right (**a**) and left (**b**) femurs. By convention, position 3 is always located on the medial surface of the segment, and position 12 anteriorly. Applying this guideline avoids failure in designating the positions on the right and left extremities. According to the topographico-anatomic features of the humerus and femur, positions 2, 3, 4, and 5 can only be imagined theoretically at levels 0 and I (and in some individuals, also at level II)

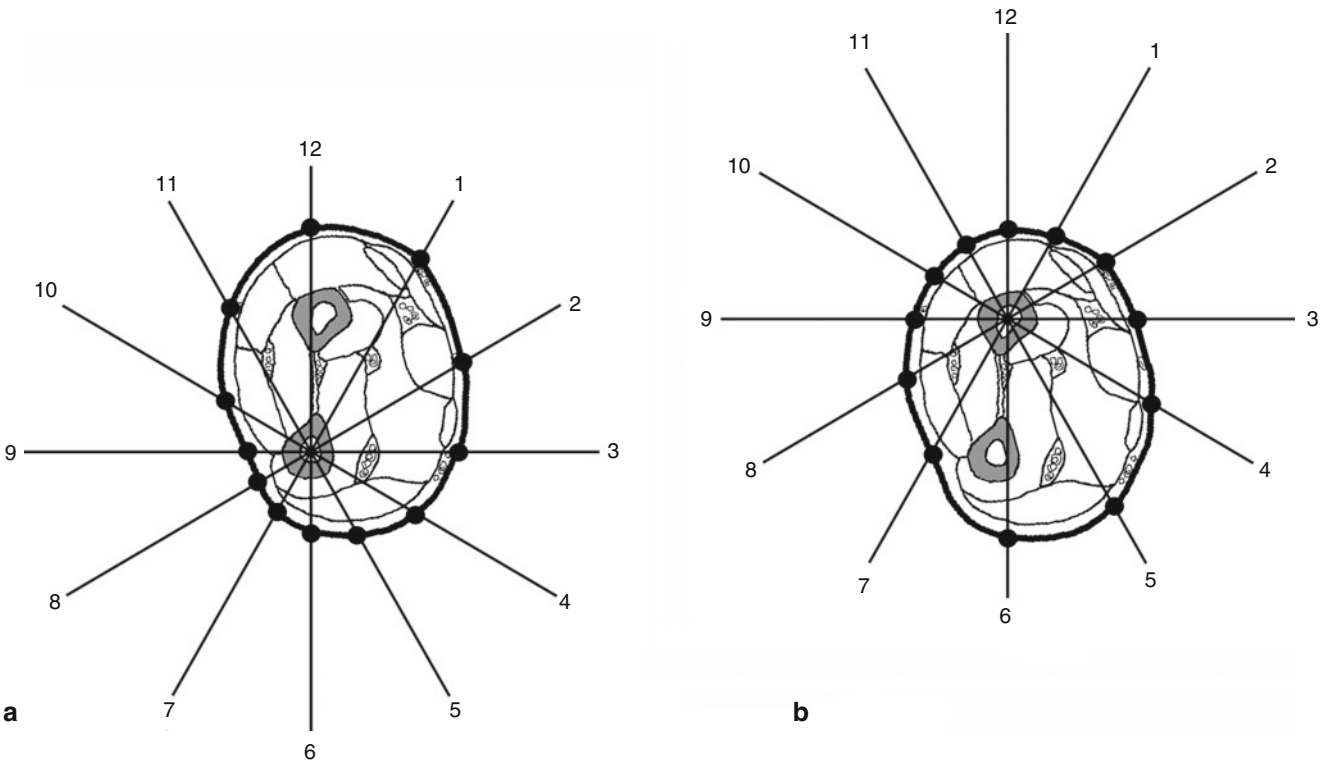


Fig. 4.4 Designation of positions on the ulna (**a**) and radius (**b**) at level IV of the right forearm in the mid-position between supine and prone. Thus, 24 positions are indicated at each of the ten levels of the forearm and the lower leg: 12 positions relative to each bone of the segment

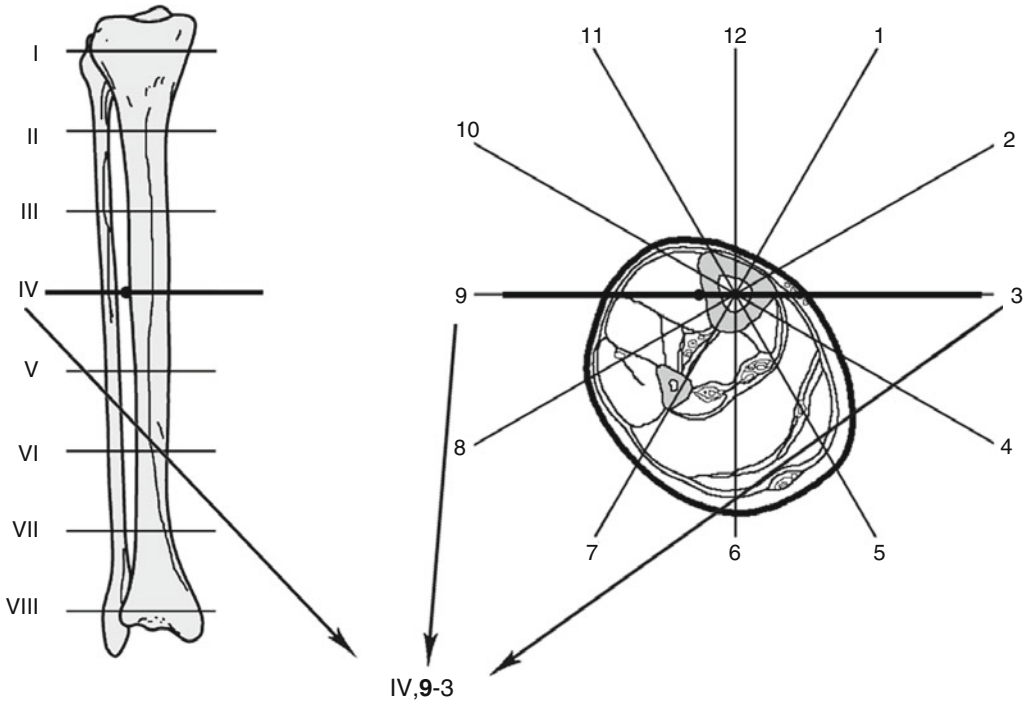


Fig. 4.5 For the designation of wires passing perpendicular to the long axis of the segment, the following conditions must be marked: level of passage and, after a comma, the two positions through which it is consistently passed. Positions through which a wire is consistently passed are separated using an en dash (–). A wire with an olive is designated by the indicating the corresponding position in *bold type*. This designation is the clarifying one. For example, if a K-wire with an olive is passed at level IV in the frontal plane, in a lateral to medial direction, then it is designated IV,**9**-3

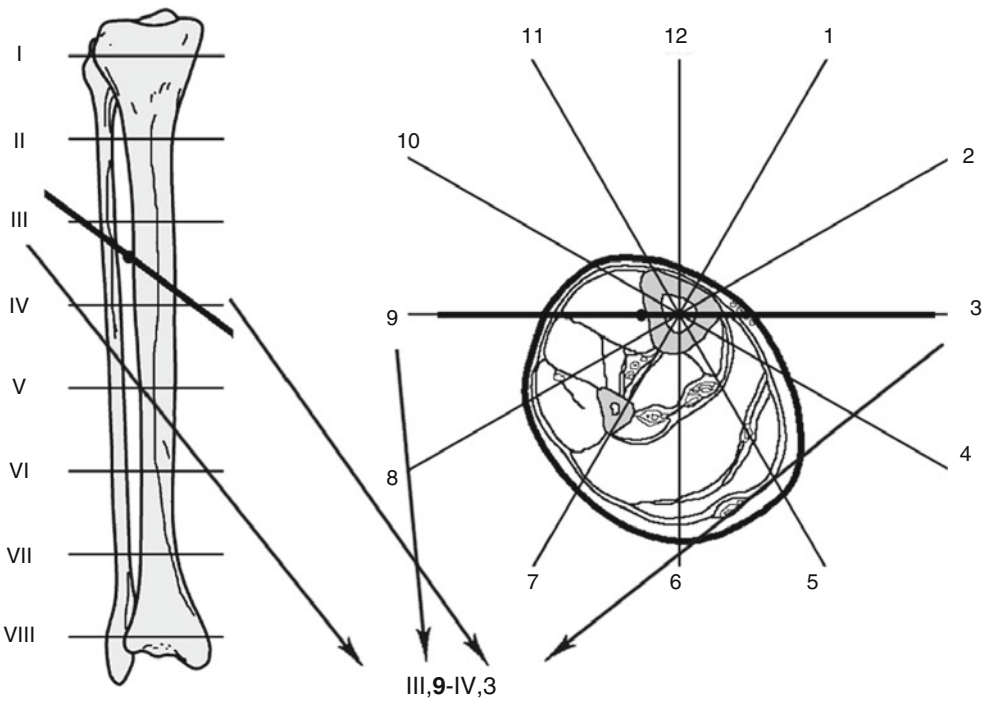


Fig. 4.6 If a wire with an olive is passed at an angle to the long-bone axis, that is from one level to another (for example, from level III to level IV) in a lateral to medial direction, then it is designated II,**9**-IV,3

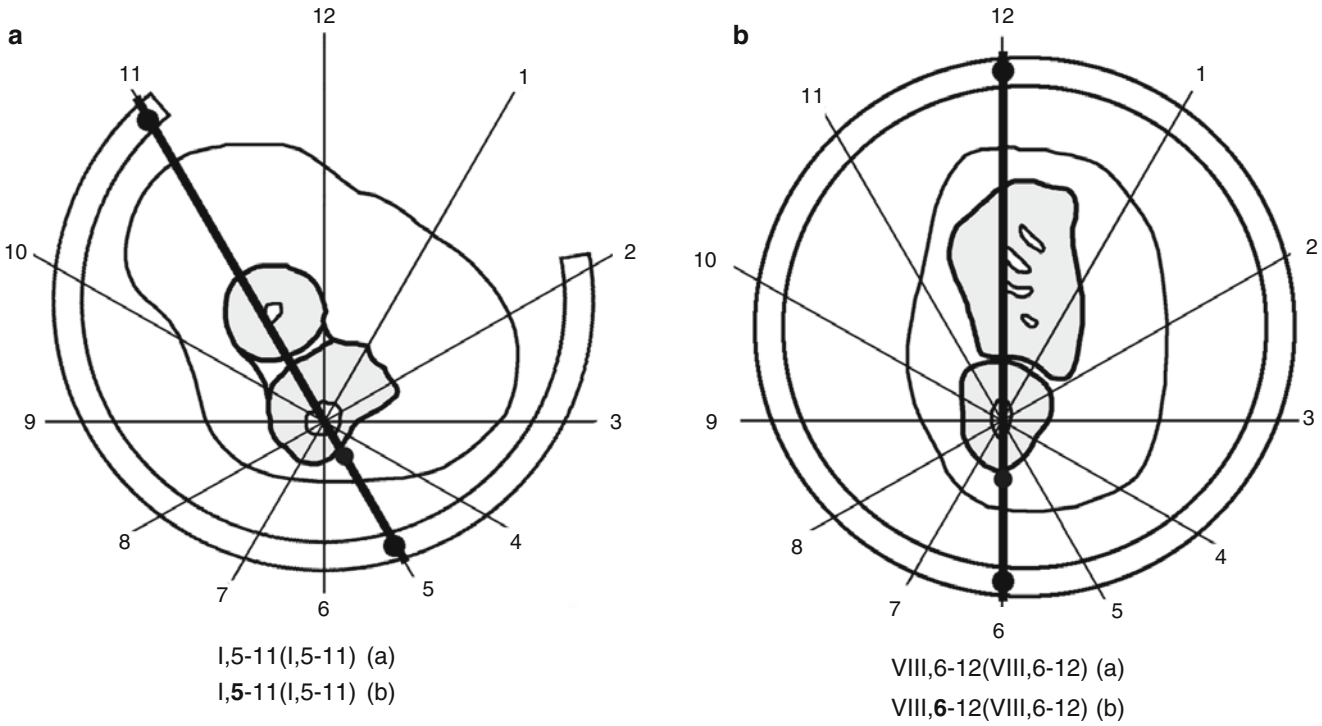


Fig. 4.7 (**a**, **b**) Designation of wires passing through both bones of the forearm in standard (**a**) and clarifying (**b**) variants. Positions relative to the radial bone are not shown. In the mid-position of the forearm (between supine and prone), at the majority of levels (except level I), the ulna and radius are located one above the other. Consequently, positions 6 and 12 of both bones are also located one above the other. In this case, a wire with an olive passing at level VIII from the side of the ulna can be represented as shown in (**b**): position 6 of the ulna → position 12 of the ulna → position 6 of the radius → position 12 of the radius. That is why the VIII,**6**-12 designation corresponds to a wire through the ulna. Doubling the designation by adding a designation in parentheses (VIII,6-12) shows that the wire passes through the radius as well. If a wire with an olive passes at level VIII of the forearm from the side of the radius, then it is designated (VIII,**12**-6)VIII,12-6. The proximal radioulnar joint is not strictly located in the sagittal plane. Consequently, the common designation for the ulna and radius at level I is axis 5–11 (and not 6–12 as for all the other levels). Thus, it is necessary to designate a wire with an olive (passing at level I, thus beginning with the ulna through both bones) as shown in (**a**). A wire with an olive passing at level I of the forearm from the side of the radius is designated (I,**11**-5)I,11-5. Note that the parts of the designation indicating the ulnar and radial portions of a wire are not separated by a space

can be used to designate a drain placed at this level in the projection of the mentioned positions.

Several positions of the ulna and radius (and the tibia and fibula) overlap. For MUDEF, this circumstance influences the designation of wires that pass through both bones of the forearm or lower leg. Thus, the same wire may need to be designated twice: once for the part that passes through the ulna (tibia) and again for the part that passes through the radius (fibula) (Fig. 4.7). Another example is "a wire with an olive passed at level VIII of the lower leg at the side of the fibula, in the projection of positions 8 and 2." Using MUDEF, this description is designated in the standard variant as (VIII,8-2)I,8-2 and in the clarifying one as (VIII,**8**-2)I,8-2.

4.4.2 Designation of Half-Pins

To accurately designate console transosseous elements (half-pins, S-screws, stiletto-formed and curved rods, and console wires) it is necessary to indicate after a comma the following (Fig. 4.8): (a) the *level* of console transosseous element insertion, (b) the *position* of its insertion, and (c) the *orientation* of its insertion in relation to the long bone axis (anatomic axis). By convention the angle is open *proximally*.

Where the console transosseous element is passed through both bones, it is designated using the symbol of only one position because the skin is perforated only on one side; for example, VIII,6,90(VIII,6,90) (Fig. 4.9). This differs from the designation of a wire passing through both bones (Fig. 4.7).

4.5 Designation of the External Support Frame

To encode the device supports, the designations of each transosseous element (K-wire, S-screw) fixed to the common support are separated by semicolons and spaces (Figs. 4.10 and 4.11).

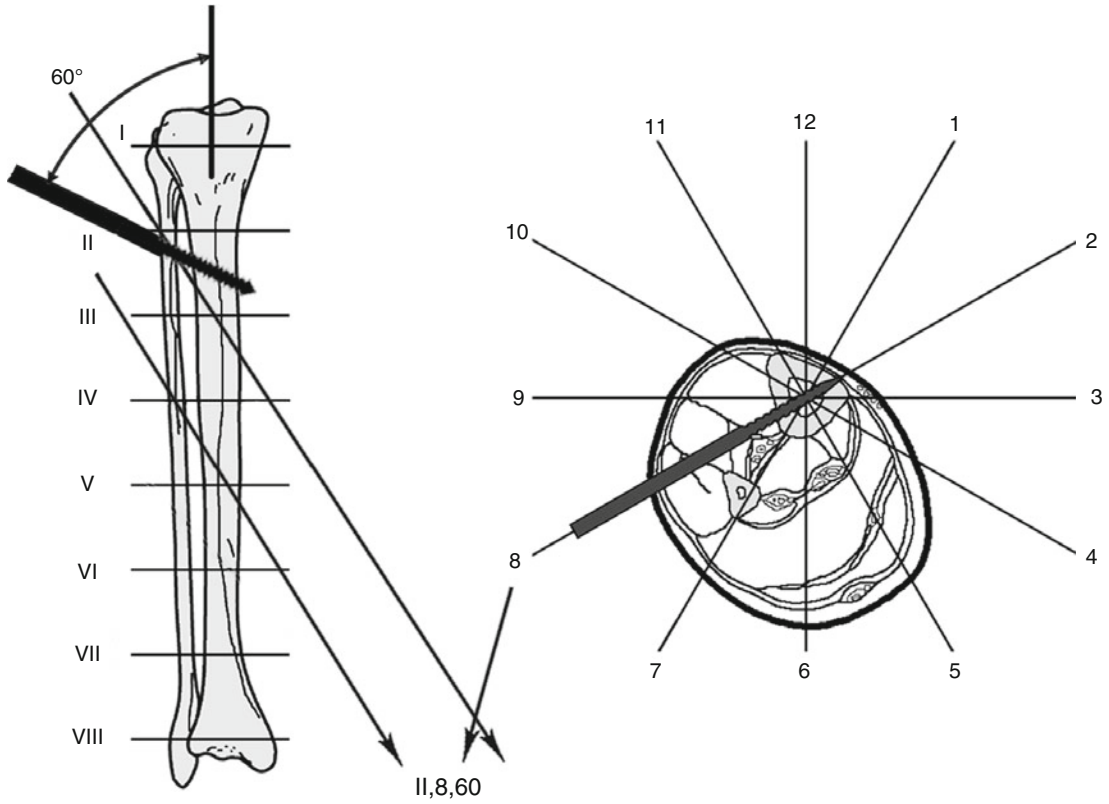


Fig. 4.8 Designation of a half-pin inserted at level II in the projection of positions 8, at an angle of 60° to the longitudinal (anatomic) axis of the tibia

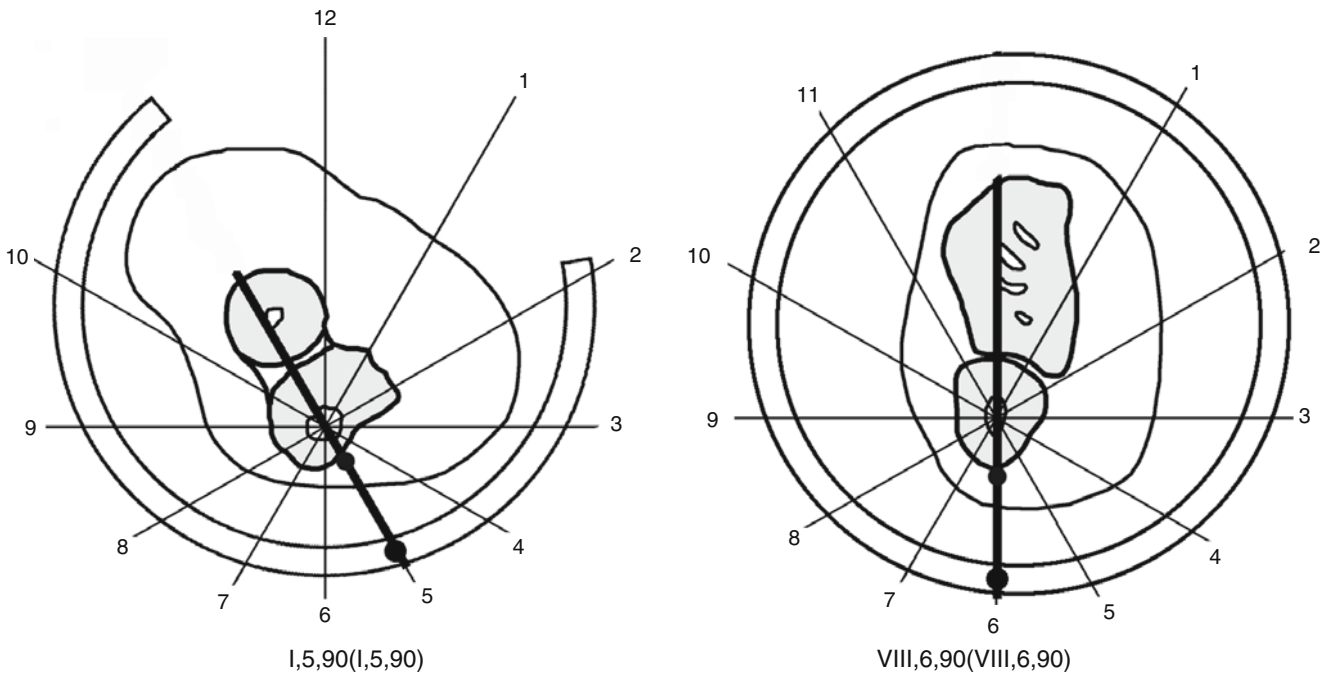
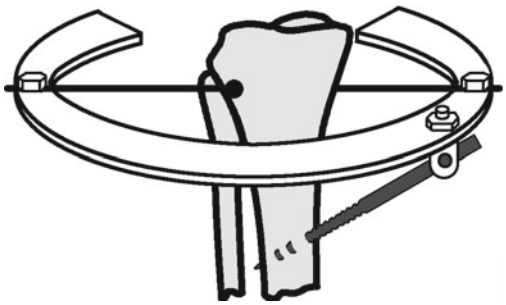


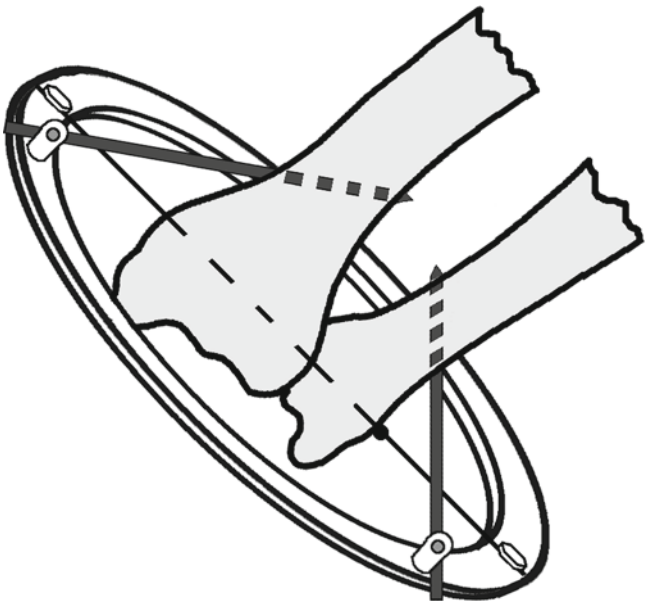
Fig. 4.9 Examples of the designations of console wires passed through the bones of both forearm. The positions relative to the radius are not shown



I,9-3; II,1,60 (a)

1 2
I,**9**-3; II,1,60 (b)
3/4 150

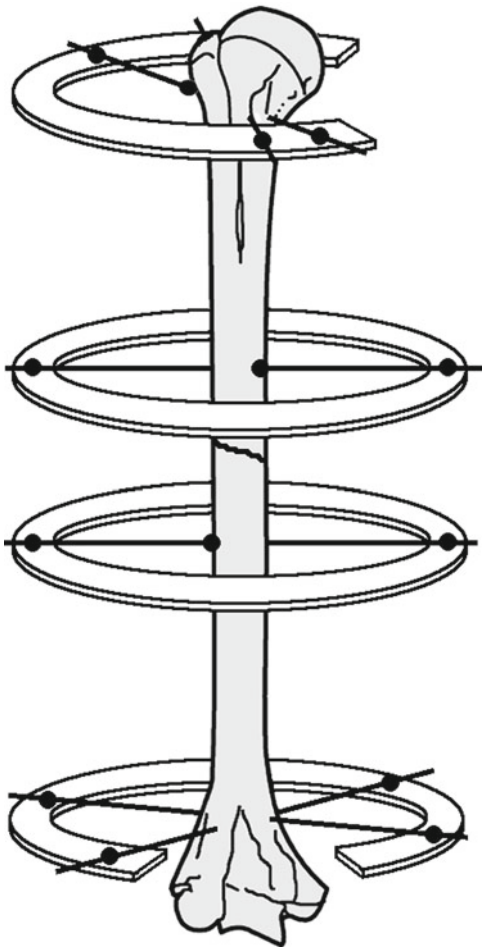
Fig. 4.10 Example of the designation of a hybrid (wire/half-pin) support in standard (**a**) and clarifying (**b**) variants. When the additional symbols are used, all the designations of the transosseous elements fixed to the present support must be united below using an *unbroken line*. To designate the order of insertion of the transosseous elements (sequence for performing the osteosynthesis), numbers corresponding to the order of priority in which the transosseous elements are passed are given above the designation of the wires and half-pins. Under the unbroken line, the other additional symbols define both the form (geometry) of the support (for example, 3/4 defines a three-quarter circle, i.e., minus a 90° section; 1/2, a semicircle) and the dimensions (in mm) of the support (for example, the diameter of the circle support)



(VII,11,120); VII,8,120; VIII,6-12(VIII,6-12) (a)

2 3 1
(VII,11,120); VII,8,120; VIII,**6**-12(VIII,6-12) (b)
120

Fig. 4.11 Diagram of a support mounted at level VIII of the forearm in standard (**a**) and clarifying (**b**) variants according to the description: "K-wire with an olive from the side of the ulna is passed through the distal metaphyses of both forearm bones. S-screw is inserted into the radius at level VII in the projection of position 11 at an angle 120°. The second S-screw is inserted into the ulna at level VII in the projection of position 8 at an angle of 120° to the long axis of the bone. All the transosseous elements are fixed to the 120-mm circular support"



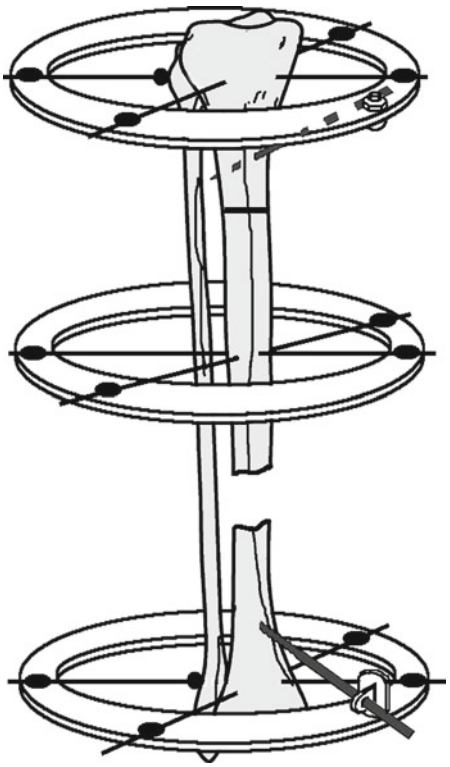
I,7-1; I,11-5 — IV,3-9 →← V,9-3 — VII,8-2; VII,10-4 (a)

1 2 5 6 3 4
I,**7**-1; I,11-5 — IV,**3**-9 →← V,**9**-3 — VII,8-2; VII,10-4 (b)
3/4 140 130 130 3/4 130

Fig. 4.12 Example of MUDEF of a humeral bone fracture 12-A3 in standard (**a**) and clarifying (**b**) variants according the description: K-wire with an olive is inserted through the proximal metaphysis of the humeral bone at right angles to the long axis of the segment and oriented at an angle 75° to the frontal plane from posterior to anterior. A second K-wire is passed in the same plane as the first at an angle 30° to it. Two K-wires are passed through the epicondylar region of the humerus at right angles to the long axis of the bone in the transverse plane and oriented at 30° to each other (the angle is opened to the outside). The Ilizarov device is mounted using three supports with a diameter of 130 mm and one (proximal) support with a diameter of 140 mm. In such cases the basic supports of the device are geometrically mounted in a three-quarter circle. To reduce the bone fragments, two K-wires with a stop are inserted in the frontal plane, the first at a distance equivalent to one-third of the length of the diaphysis from the proximal end in a medial to lateral direction; and the second at a distance one-third from the distal end in a lateral to medial direction. The interfragmental compression is given

4.6 Designation of the Entire Device

To designate the configuration of the entire device (Figs. 4.12, 4.13, 4.14, and 4.15), other symbols are inserted between those for the external supports in order to represent the



(I,8-2)I,8-2; I,4-10; II,1,60←→IV,2-8; IV,4-10 →← VII,1,120; (VIII,8-2)VIII,8-2; VIII,4-10 (a)

1 2 3 7 8 6 4 5
(I,**8**-2)I,8-2; I,4-10; II,1,60 ←→ IV,2-8; IV,4-10 →← VII,1,120; (VIII,**8**-2)VIII,8-2; VIII,4-10 (b)
150 150 150

Fig. 4.13 Designation of the bone transport operation (replacement of a tibial defect by lengthening of the proximal fragment) in standard (**a**) and clarifying (**b**) variants. Note that the designation (1,**8**-2)I,8-2 shows that the olive of the K-wire is located on the fibula. The designation of the K-wire (VIII,**8**-2)VIII,8-2 shows the same

0,3-9; 0,8-2 –o– II,2,90; IV,2,90; V,2,90 (a)

1 2 3 4 5
0,**3**-9; 0,**8**-2 –o– II,2,90; IV,2,90; V,2,90 (b)
2/3 160 mon.

Fig. 4.14 Designation of the Biomet-Merck device in standard (**a**) and clarifying (**b**) variants

Table 4.2 Symbols used to represent biomechanical relationships

Symbol	Biomechanical relationship
——	Neutral
→←	Compression
←→	Distraction
—°—	Hinge
←°→	Distraction hinge

recommended biomechanical relationship between them, as shown in Table 4.2.

4.7 Additional Data

If necessary, the number of levels and positions can be increased, for example, up to 30 levels and 360 positions. The following notes correspond to such conditions, for example: XXII,162-342; XVIII,273,65.

Besides increasing the number of levels and positions, the MUDEF user can apply the additional symbols as needed. They identify the type of console transosseous element (for example, S-screw, half-pin, hooked rod), the material (from which the external device supports and transosseous elements are made), the diameter of the transosseous elements connecting the supports of the bar, etc.

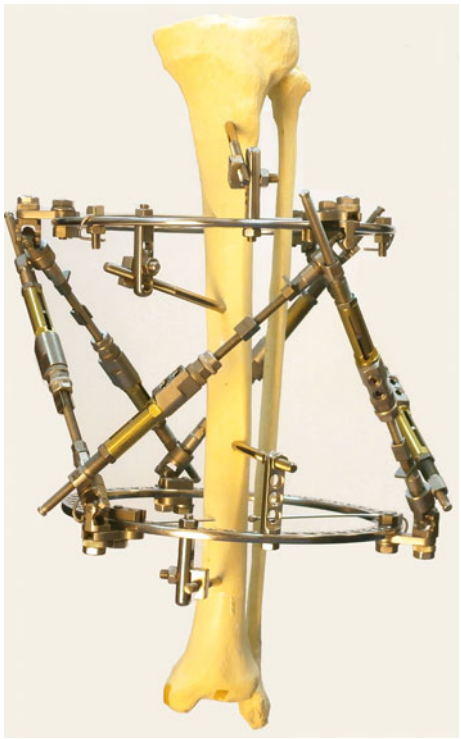


Fig. 4.15 Designation of the Ortho-SUV Frame in standard (**a**) and clarifying (**b**) variants

II,1,120; III,9-3; IV,3,70 —O-SUV — V,12,90; VI,3-9; VII,2,90 (a)

II,1,120; III,**9**-3; IV,3,70 —O-SUV — V,12,90; VI,**3**-9; VII,2,90 (b)

We recommend using the following text descriptions to designate the transosseous elements introduced into the anatomic formations not included in the given schemes:

- "Two mutually crossing wires were passed through the acromion of the scapula and fixed to one external support:" acr.,1-7; acr.,5-11
- "The half-pin was passed into the posterior surface of the olecranon at an angle 90°:" olecr.,6-90
- "A wire was passed through the talus in the frontal plane:" talus,3-9

During completion of the operative record, the only features of the procedure that need to be recorded in text form are the operative approach, the characteristics of the tissues, and any complications that arose. This procedure for the completion of the operative record results in medical documentation that is comprehensive and unambiguous, as can be seen from the records given as examples below:

- Additionally, element II,1,60 was passed and fixed to the proximal device support.
- It is recommended that contralateral compression of the fragments (1 mm/week) be performed using wire traction deviceV,9-3.
- Due to incision of the soft tissue near half-pin V,2,90, it was changed to wireV,4-10.
- The signs of inflammation appeared in the region of K-wire VI,4-10 exiting at position 4.

The last two examples illustrate the significant role of MUDEF of the long bones in the process of *objectification of complications*.

An electronic version of MUDEF can be obtained at http://rniito.org/solomin/download/mudef.zip and http://ortho-suv.org