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«Ortho-SUV» Ltd.

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Deformity Correction and Fracture Treatment by Software-based Ortho-SUV Frame

User Manual

For SUV-Software: vp. 1.0 and vr. 1.0

Saint-Petersburg, 2013

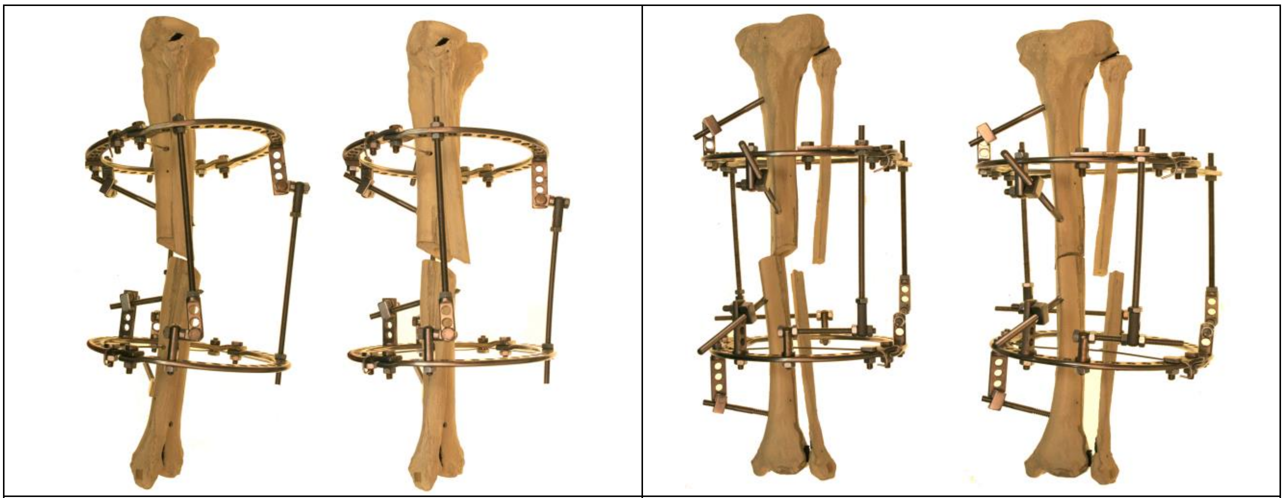
www.ortho-suv.org

Contents

1. Introduction

In the correction of complex multi-component and multiplanar deformities (http://www.ortho-suv.org/images/stories/deform_class2.jpg) using the Ilizarov frame, unified reduction nodes have to be replaced three to five times (Fig. 1). Every frame re-assembly involves a change in the reductional units and is a highly laborious process in which there is additional patient exposure to radiation. Sometimes, due to the peculiarities of frame assembly (external supports are not oriented at a right angle to the axes of the bone fragments, a bone is not at the center of a support, the support for some reason is not closed, etc.), correction of one component can lead to the secondary translation of other(s). These secondary translations will, in turn, require correction and therefore additional frame re-assembly [Solomin L.N. et al., 2009].

a b



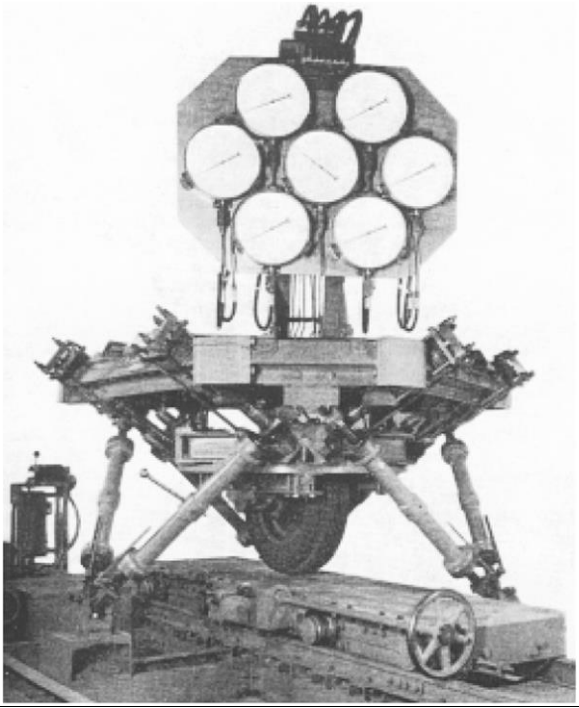
c	d

Fig. 1. To correct a multi-component deformity, the Ilizarov frame has to be reassembled three to five times. **a** – lengthening. **b** - correction of an angular deformity and translation in the frontal plane. **c** - correction of an angular deformity and translation in the sagittal plane. **d** - correction of a rotation

Certainly, the problem of the directed accurate moving of object in three-dimensional space demands the decision not only in orthopedic surgery, but also in many branches of technique. One of perspective directions in the given area is application of ***hexapods***. Hexapods structurally consist of two (basic and mobile) platforms to be connected by six telescopic rods of a special design, so-called *struts*.

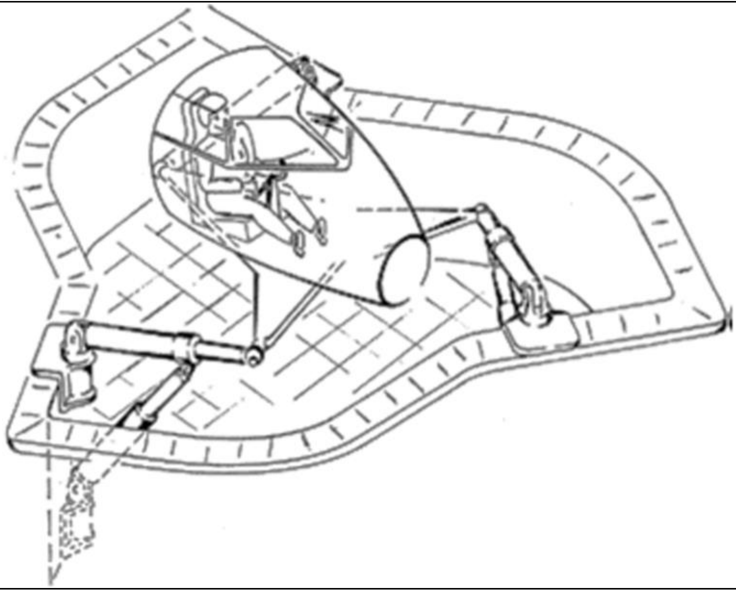
The ways in which the struts connect to each other and to the platforms differ and depend upon the author’s approach (Fig. 2). The number of struts is not connected with the number of planes and the degrees of freedom that the platforms must have relative to each other: when five struts are used, the system loses its stability, while seven struts causes overstraining.

The first hexapod was proposed by Gough in 1947 [Bonev I., 2003] for testing wheels exposed to combined forces (Fig. 2a). Ceppel, in 1962, unaware of Gough’s invention, created a similar mechanism while developing a vibration device (Fig. 2b). Stewart, in 1965 [Bonev I., 2003], proposed a platform on the basis of the original hexapod (Fig. 2c).



a

b



c

Fig. 2. Hexapods. **a** - Gough's system. **b** - Ceppel's system. **c** - Stewart's platform [Bonev I., 2003]

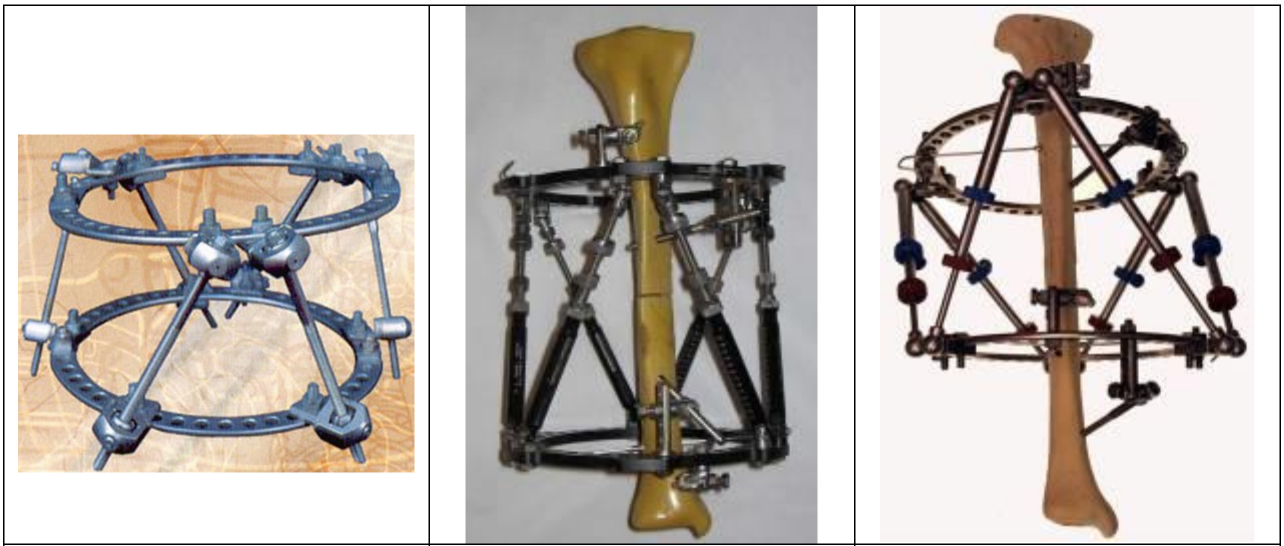
Initial length of each of struts corresponds to initial position of a mobile platform; final length of each of strut agrees with needed position of mobile platform. Change of length even of one strut leads to displacement mobile platform relative to basic one in three planes. Therefore for necessary displacement of a mobile platform relative basic needs computer navigation. The task of the software is to calculate required change of length of each strut using some data input.

There are active and passive navigation in robotics. With reference to considered devices at *active navigation* the computer, having received necessary coordinates of due position of an object (in this case - a mobile platform) takes all necessary parameters for achievement of result "itself". If the operator approves modeled result, the device for active computer navigation steers a mechanism to carry out the directed movement. The autopilot works in the same way.

At *passive navigation* the operator put in a computer necessary coordinates of position of a mobile platform and parameters to describe its initial position, including initial strut lengths, as well. After that the software calculates necessary change of lengths for each of strut. Then the operator changes length of each of strut, to achieve due position of mobile platform. A car navigator may serve as an example.

In orthopedics, the hexapod may be considered as an universal reduction unit to allow the movement of one platform (one basic support, with the bone fragment fixed inside) relative to another by the shortest “integral” trajectory. The first “orthopedic hexapod” was patented in 1985 in France by Philippe Moniot [Paley D., 2011]. At the beginning of 90th years of the last century in the Ilizarov Russian Research Center the device shown in Fig. 3a was developed [Shevtsov V.I., 2008, unpublished data].

However, these frames were not clinically used, partly due to the lack of software.



a b c

Fig. 3. Orthopedic hexapods. **a** – device created in Ilizarov Russian Research Center. **b** – Taylor Spatial Frame. **c** - Ilizarov Hexapod System

First orthopedic hexapods, used clinically and sold commercially, appeared in USA and Germany. Those are Taylor Spatial Frame – TSF (Fig. 3b), with its usage started in 1994 and Ilizarov Hexapod System device – IHS (Fig. 3c), developed in 1995 [Seide K. et al., 1999]. These devices are becoming more and more popular at fracture treatment and long bone deformity correction due to the possibility to implement mathematical precision of the procedure without resorting to repetitive changes of unified reduction units [Paley D., 2005; Rozbruch, S.R. et al., 2006; Marangoz S. et al., 2008; Seide K. et al., 2008; Solomin L.N. et al., 2008; Dammerer D. et al., 2011]. Original transosseous hexapod (Ortho-SUV Frame) was developed in Russia in 2006.

There is an incorrect opinion, that all known orthopaedic hexapods work using Stewart platform [Taylor J.C., 1997; Seide K. et al., 1999; Paley D., 2005]. However, IHS and TSF are closer to Gough's and Ceppel's platforms (Fig. 2a,b). Ortho-SUV Frame reminds Stewart platform from outside. This device was made on the basis of *Solomin-Utekhin-Vilensky platform* (SUV-Platform), featuring unique construction and kinematics. Only 3 struts connect to each ring. The other 3 struts connect to the side of another strut. The information about the distance between the sides of the triangle formed at each ring by the strut connection is fed into the computer. Because only 3 struts connect to each ring, thus forming a triangle between the connection points, the computer identifies a plane for each triangle using only the strut lengths and the length of the sides of the 2 triangles. The beauty of this frame is that for the first time it is independent of the size and shape of the rings and the math is much easier. This is by far the most modular of all the 6 axis correction frames [Paley D., 2011].

Due to improvements, Ortho-SUV Frame succeeds its analogs by a number of design features, its reductive potential and rigidity of the osteosynthesis. Additionally, Ortho-SUV Frame is equipped with advanced software.

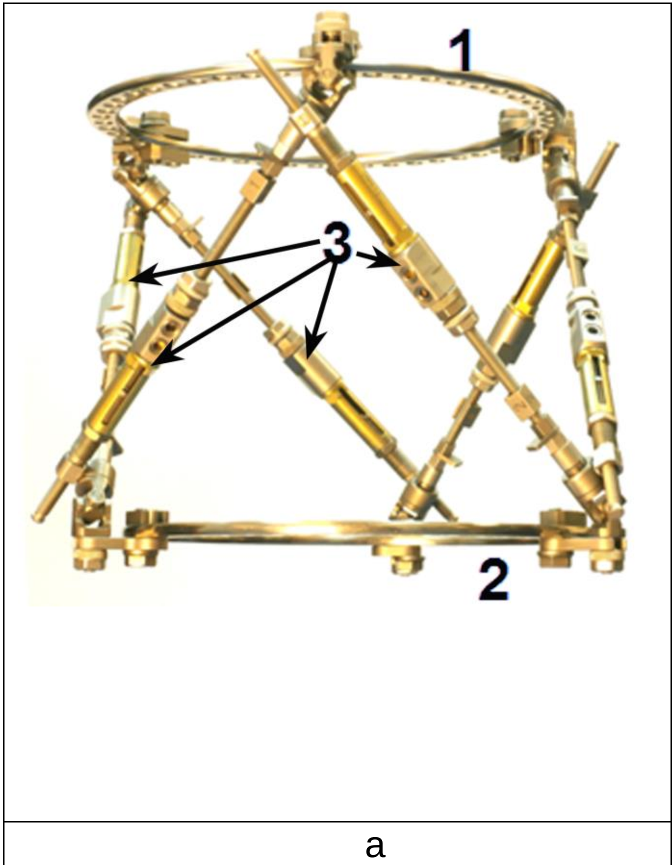
Indications for application of Ortho-SUV Frame

1. Fractures (except intra-articular):
   - Closed fractures;
   - Open fractures;
   - Open fractures in conjunction with soft tissue damage such as burns, soft tissue extensional defects;
2. Consequences of the fractures:
   - non-unions;
   - malunions;
   - posttraumatic deformities;
   - osteomyelitis, including bone defects;
3. Long bone deformities:
   3.1. congenital deficiency (fibular hemimelia, congenital femoral deficiency, tibial aplasia etc.);
   3.2. Aquired deformities:
   -post traumatic;
   -post infectious;
   - idiopathic;
   - bone diseases leading to deformity (Hypo-, Pseudo-, Achondroplasia; Rickets; Blount; enchondromatosis; mucopolysaccharidosis etc.);
4. Congenital limb length discrepancies;
5. Foot deformities (including clubfoot; Charcot-Marie Disease etc.);
6. Joint stiffness of elbow, knee and ankle joints of any etiology;
7. Old subluxations in elbow, knee and ankle joints;
8. Aesthetic deformities;
9. Reconstructive procedures (for example: pelvic support osteotomy);
10. Arthrodiastasis.

Further information featuring construction and advantages of hardware and software will be considered below.

2. Design of Ortho-SUV Frame

Two external supports comprise the Ortho-SUV Frame (Fig. 4), one basic and the other mobile. These are united by six struts connected in series. Together, these parts constitute the "universal reduction unit" mentioned above. The basic ring, with the aid of the transosseous elements, fixes the main bony fragment, while the mobile support holds the bony fragment to be transported. If necessary, the rigidity of the osteosynthesis can be increased by using additional stabilizing supports.



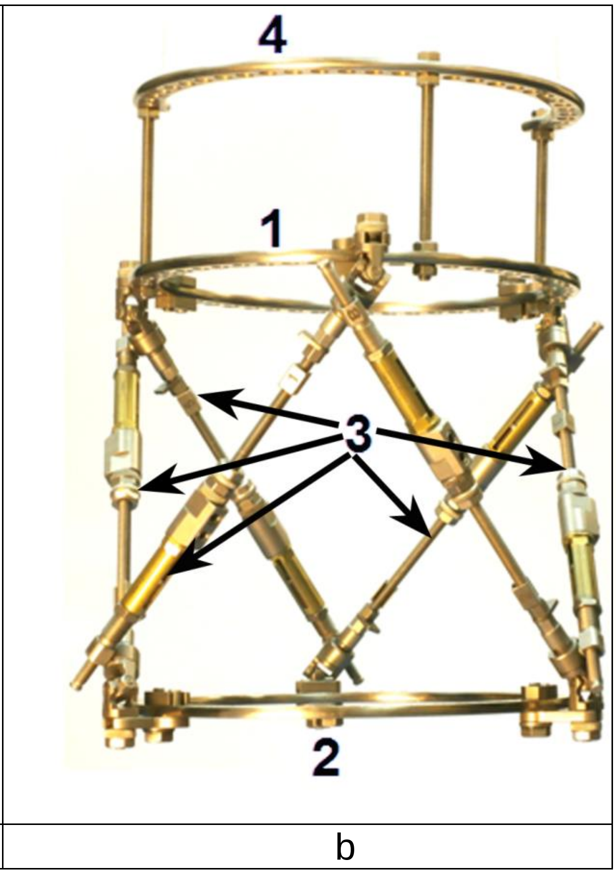
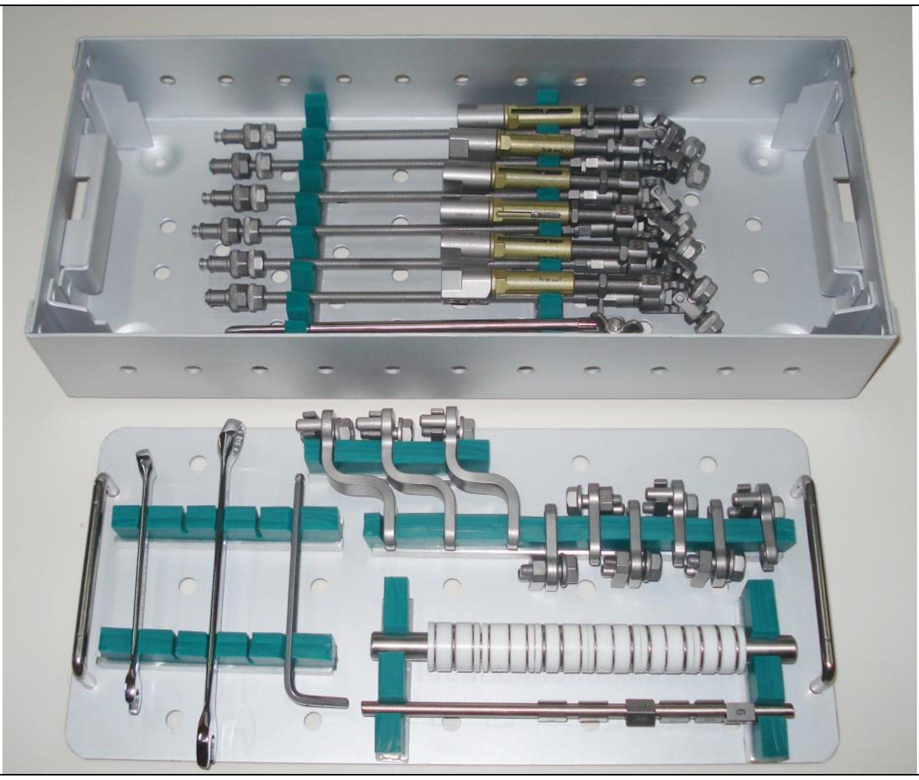


Fig. 4. Ortho-SUV Frame design. **a** – standard assembly. **b** – assembly completed with stabilizing support. 1 – basic (proximal, reference) support; 2 – mobile (distal, corresponding) support; 3 – struts; 4 – stabilizing support

Ortho-SUV Frame's standard set (Fig. 5) includes:
- six standard(medium) size struts;
- six ring connection plates straight;
- three ring connection plates Z type;
- labels of strut numbers (set of 6);
- X-ray markers of struts (set of 6);
- two spanners 12 mm;
- two spanners 8 mm;
- triangular measurement device;
- Allen key;
- hasp-key (Fig. 25).



a

b

c d

e f

Fig. 5. A standard Ortho-SUV Frame’s set. **a** – the full set. **b** – struts. **c** - plates (straight and Z-shaped). **d** – strut number clips and X-ray positive strut number markers. **e** – wrenches and a screwdriver. **f** – triangular measurement device

Strut length changing units of short and long sizes, a set of threaded rods of various lengths (Fig. 6) can be taken additionally.

Fig. 6. Additional equipment: threaded rods of different lengths

2.1 Design of strut of Ortho-SUV Frame

A strut consists of three main elements: a joint, a threaded rod M6 and a strut length changing unit (Fig. 7)

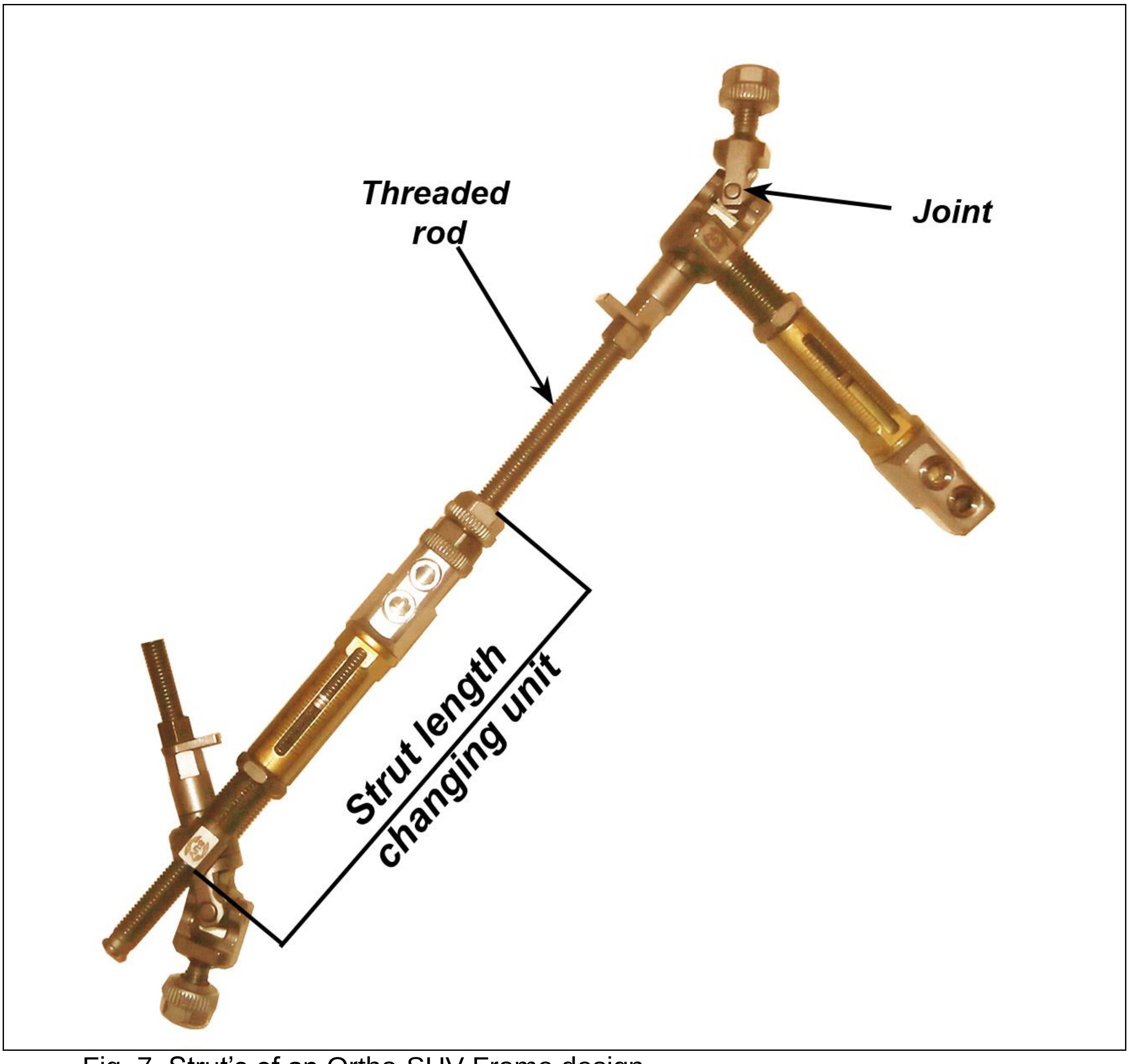
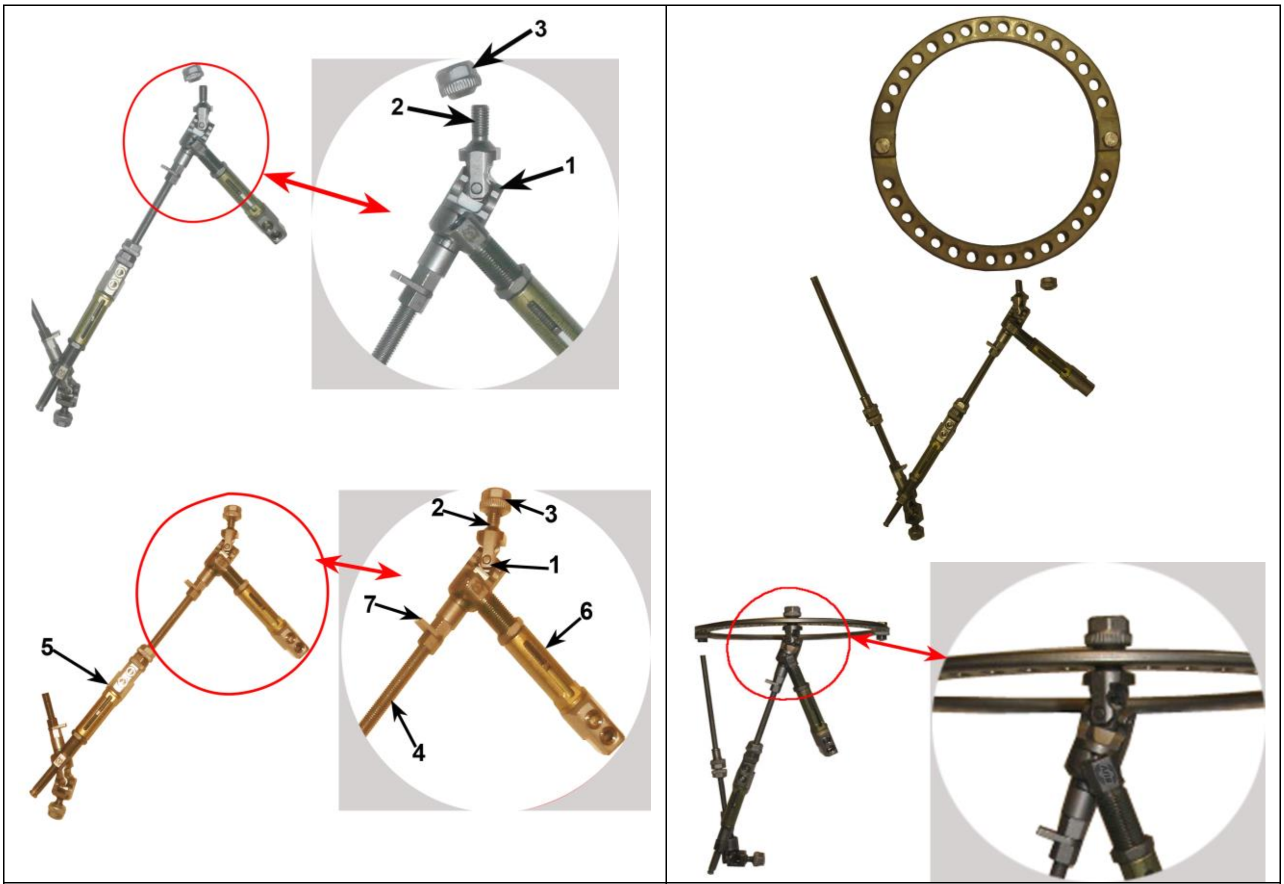
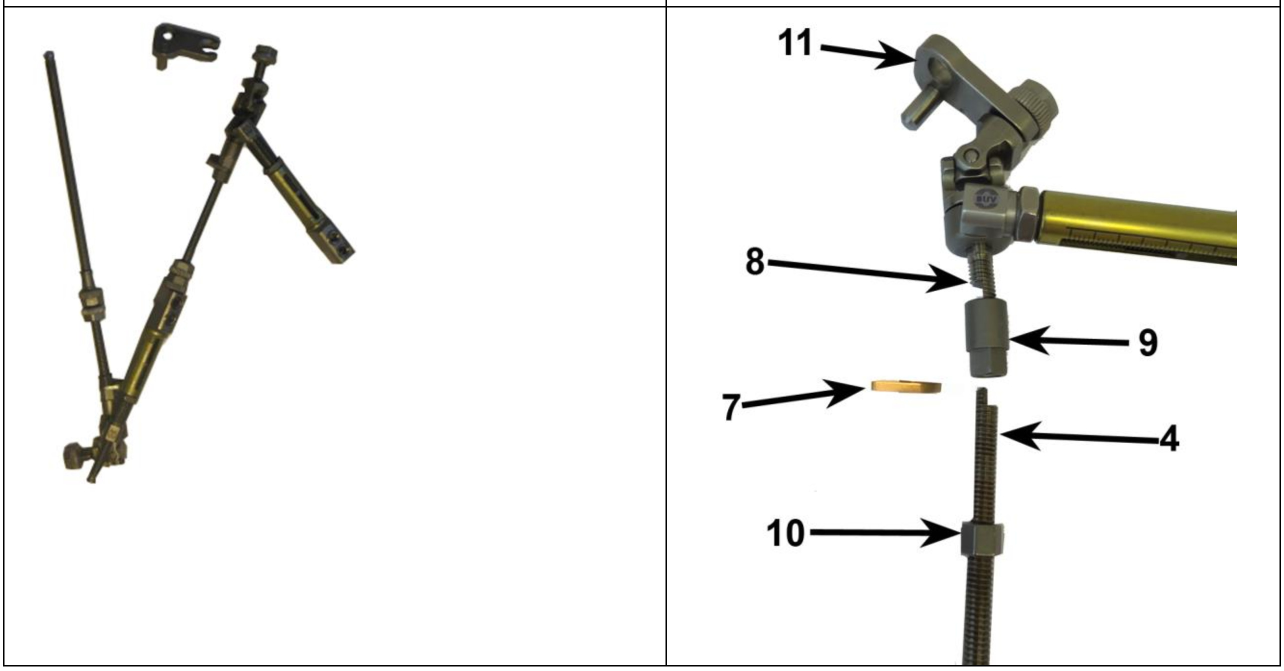


Fig. 7. Strut's of an Ortho-SUV Frame design

Joint (Fig. 8) is fixed to a ring of the frame or to plate by means of a nut. Other end of joint with the help of coupling is connected to threaded rod. There is a swivel connection of joint with strut length changing unit in this place as well. The hook used for measurement of strut length is fixed to the joint by means of a nut.



a	b



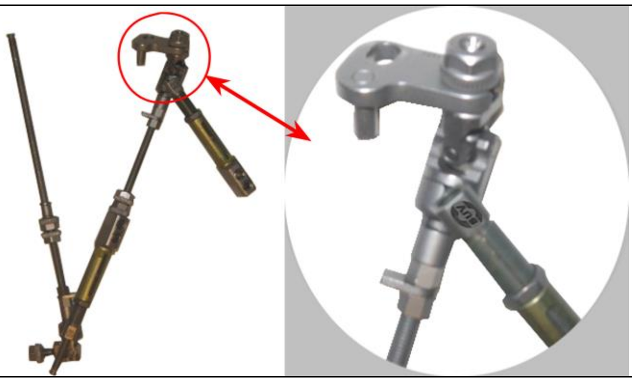
	
c	d
	
e	

Fig. 8. Design of a joint of Ortho-SUV Frame’s strut. **a** – the joint with swivel connection to strut length changing unit of the next strut. **b** – fixing a strut to the ring. **c** – fixing strut to the plate. **d** - disassembled clutch. **e** - assembled clutch. 1 – joint; 2 – threaded tail; 3 – fixing nut; 4 – threaded rod; 5 – strut length changing unit; 6 – strut length changing unit of the next strut; 7 – hook; 8 – threaded tail with L-shaped groove; 9 – coupling; 10 – small lock-nut; 11 – straight plate

Strut length changing unit (Fig. 9) consists of a body, a connecting nut, a threaded clutch and lock-nuts. The body and threaded clutch have 12 mm rust flies.

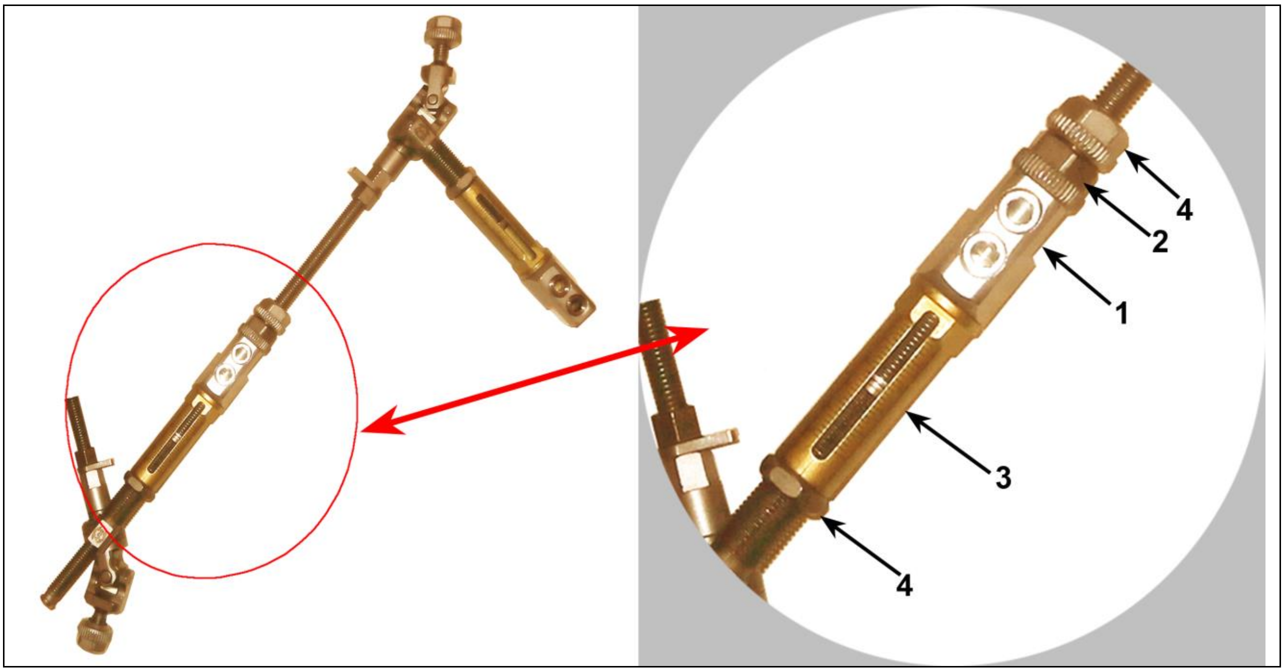
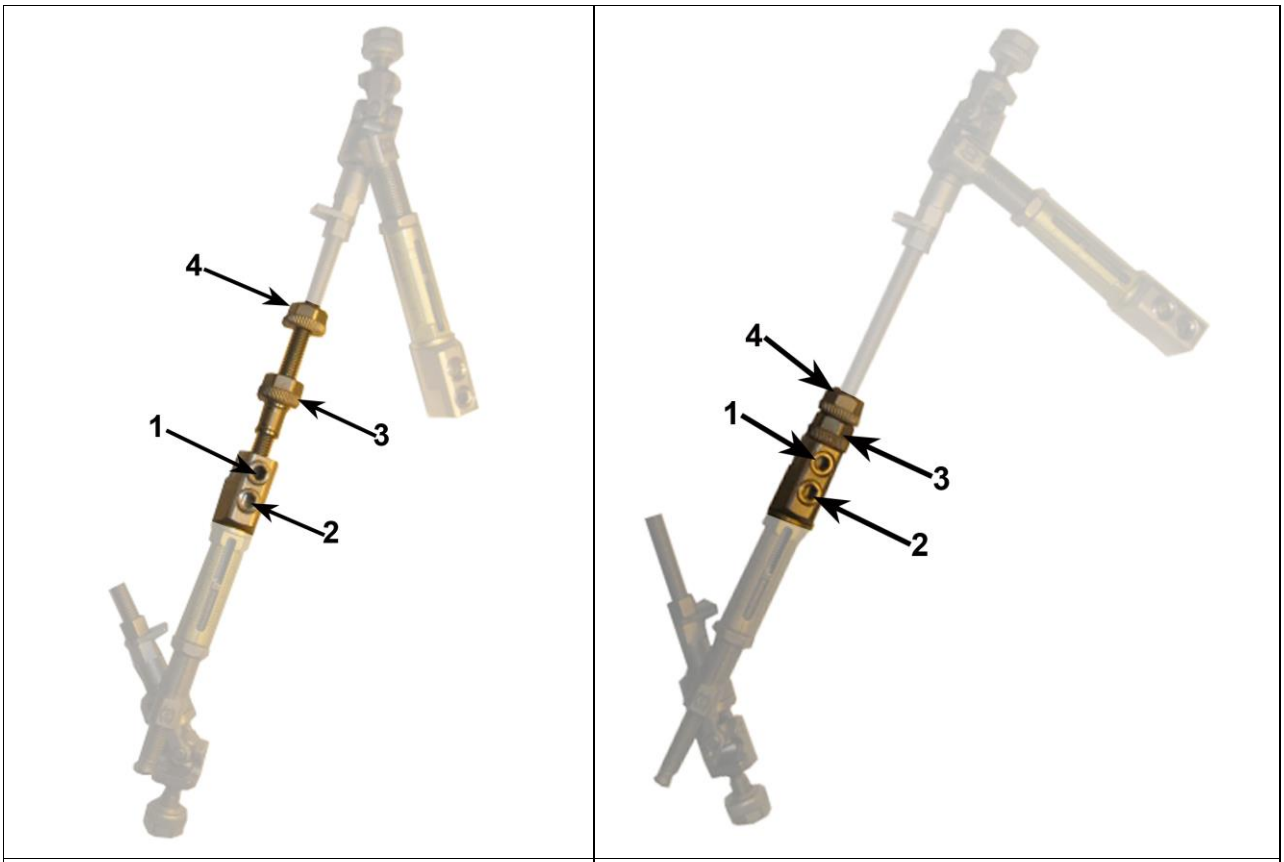


Fig. 9. Strut length changing unit. 1 – body; 2 - connector nut; 3 - threaded clutch; 4 - lock-nuts

The body encloses two screws. The screw #1 provides a mode of fracture reduction ("fast strut" mode) (Fig. 10). At a relaxation of the screw #1, connector nut can be moved (by rotation) along threaded rod (Fig. 10). There is a lock-nut over the connector nut.

The screw #2 is intended for "adjustment" ("reverse") of strut (Fig. 10).

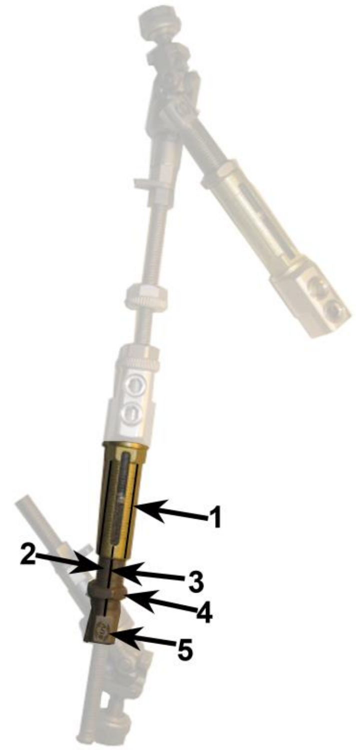
The tightening of the screw #2 fixes the body to the threaded clutch and they rotate together.



a	b

Fig. 10. Body of strut length changing unit. **a** - the screw #1 is loose; connector nut is moved away from the body. **b** - connector nut is moved into the body, screw #1 and lock-nut are fixed. 1 - screw #1; 2 - screw #2; 3 - connector nut, 4 - lock-nut

The clutch of strut length changing unit (Fig. 11) consists of two right threaded cylinders (external and internal). The external cylinder has a scale with a division value of 2 mm. In addition there are arrows "+" and "-", and eight longitudinal lines. The internal cylinder has a strut length change indicator. It moves inside the scale of the external cylinder. There is a longitudinal line on the internal cylinder as well. External end of internal cylinder is pivotally connected to the joint of *previous* strut. The logo "SUV" is applied here (Fig. 11).



a

b

c

Fig. 11. Clutch of strut length changing unit. **a** – view in coronal plane, lock-nut is moved away from external cylinder. **b** – view in sagittal plane, lock-nut fixes the external cylinder. 1 - the external cylinder with the scale, arrows "+" and "-", and eight longitudinal lines; 2 - internal cylinder; 3 - longitudinal line of internal cylinder; 4 – lock-nut; 5 - "SUV" logo;

2.2 External supports

Supports from any circular external fixation devise may be used to assemble an Ortho-SUV Frame (Fig. 12a,d,g). Additionally, supports comprising 1/2, 2/3, and 5/8 of a ring (Fig. 12b,e) are possible to use, as well as supports of any shape: triangular, oval, or rectangular (Fig.12 c,f,h).

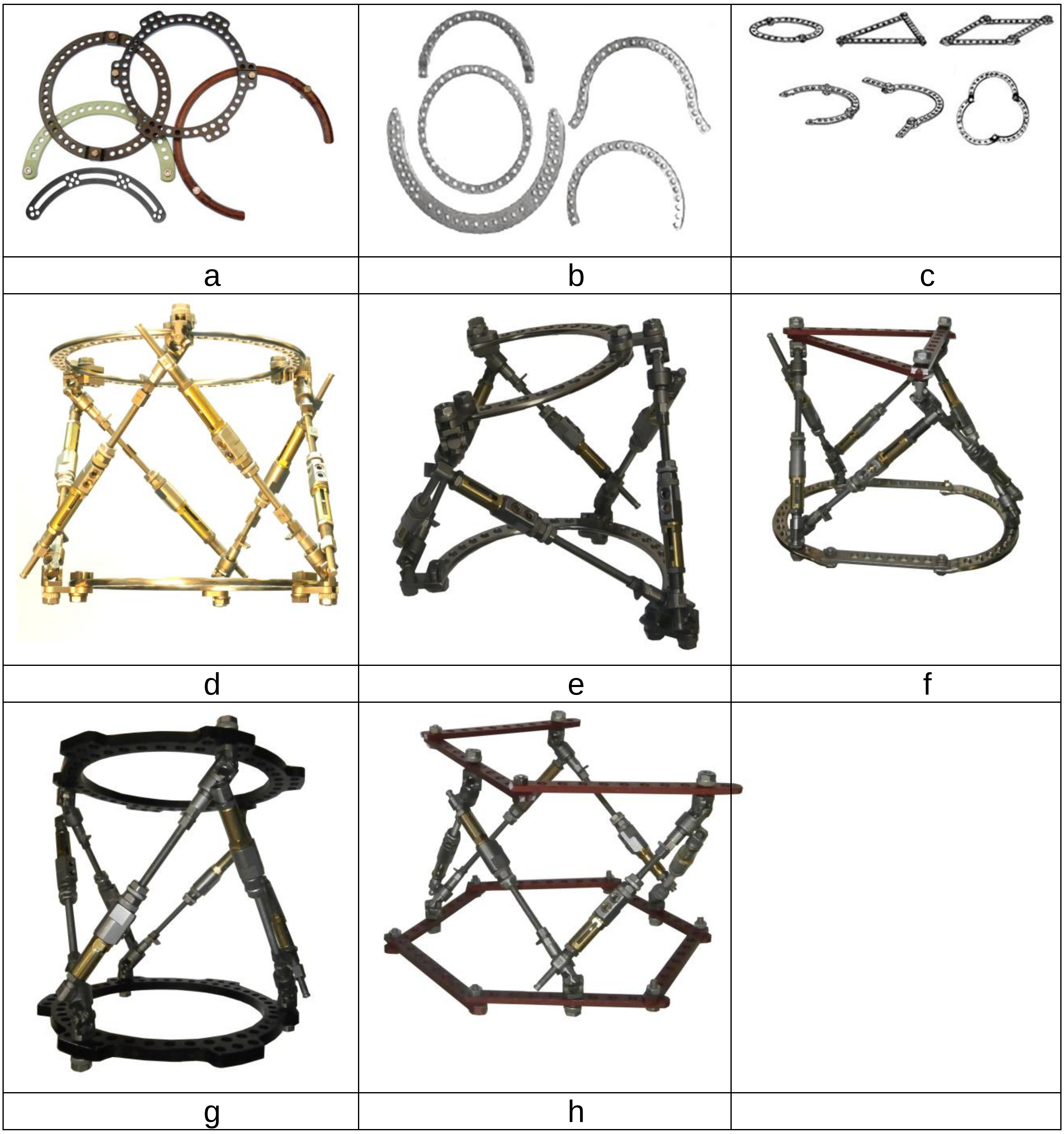


Fig. 12. In the assembly of an Ortho-SUV Frame, supports of various shapes and types can be used. **a,d,g** – supports from a range of circular external fixation devices. **b,e** –1/2, 2/3, 5/8 rings. **c,f,h** – oval, triangular, and polygonal shaped supports

3. Ortho-SUV Frame Assembly

The number of supports in frame modules as well as the number and type of transosseous elements to insert in each case are chosen on the basis of knowledge in the biomechanics of external fixation and following principles of a method of external fixation frame assembly (Solomin L.N., 2008, 2013).

NB!

Each bone fragment must be strongly fixed to rings. Rigidity of fixing of each bone fragment to a ring should exclude errors of correction of deformation due to displacement of the bone fragment inside the ring. For example, it happens because of insufficient number of wires and half-pins and (or) their incorrect spatial orientation.

3.1 Supports Assembly

Any angle of support assembling is possible. Bone fragments can be located both in the external support centre, and off the ring centre (Fig. 13).

	
a	b

Fig. 13. At Ortho-SUV Frame assembling rings can be placed both perpendicular to an axis of bone segment and at any random angle, bone fragments can be located in the centre of rings and off the ring centre as well. **a** – AP view. **b** – Lateral view

3.2 Strut assembling

NB!

For simplification of strut connection, they should be preassembled as it is shown in Figs. 5b and 14a. A "preassembled strut" consists of a joint, a threaded rod and attached to the joint strut length changing unit of the next strut.

All the six preassembled struts are interconnected as it is shown in Fig. 14b. Special dismountable strut number labels (clips) are used for designation of number of each of struts (Figs. 5d and 14a).

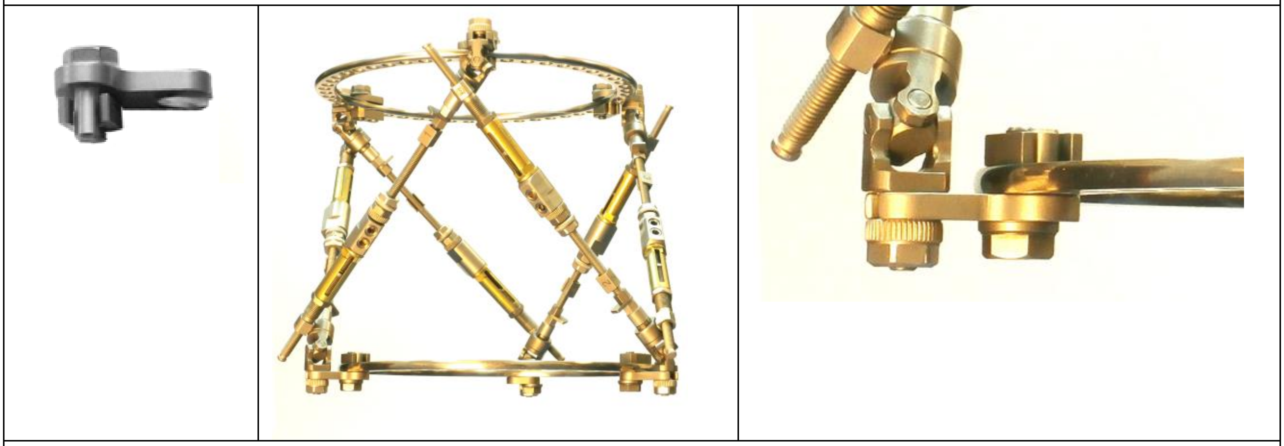
a

b

Fig. 14. Set of struts for Ortho-SUV Frame. **a** – full set, with arrows pointing the clips indicating strut number. **b** – interconnected struts

Struts can be fixed to the ring directly, and by means of straight or Z-shaped plates as well (Fig. 15).

a



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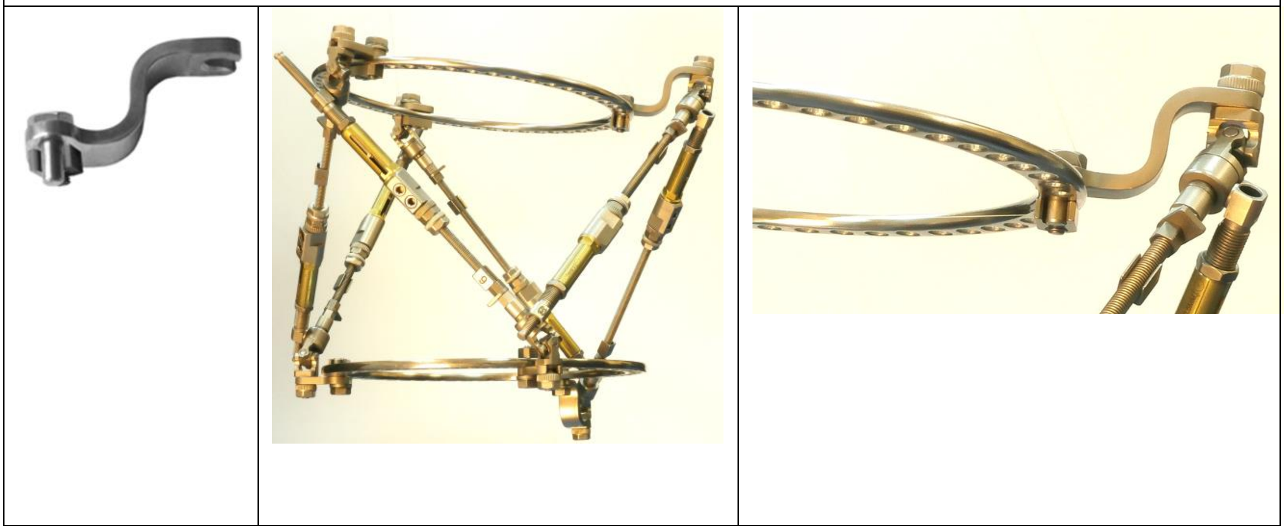
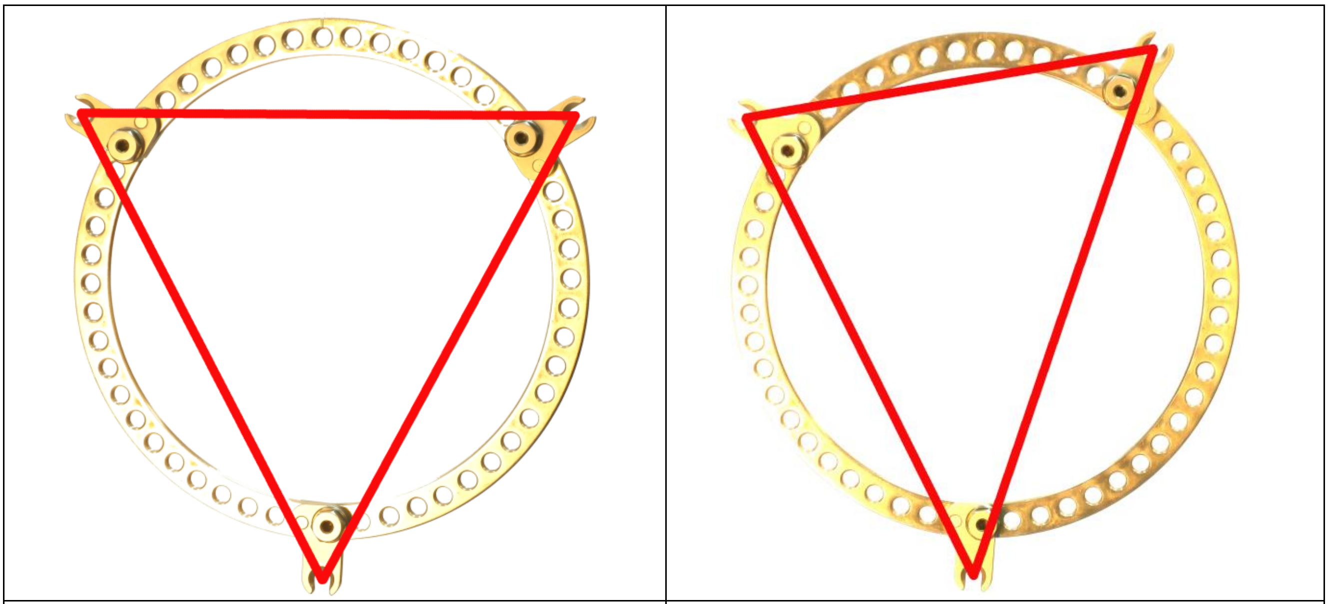


c

Fig. 15. Variants of strut fixation to support. **a** - directly to ring. **b** - by means of straight plate. **c** - by means of Z-shaped plate

Struts are fixed to the basic and the mobile rings at three points. Struts ##1, 3 and 5 are fixed to the proximal (basic) ring. Struts ##2, 4 and 6 are fixed to the distal (mobile) support. The standard of frame assembly is the joint of strut #1 located at any point of the front semicircle of the basic ring.

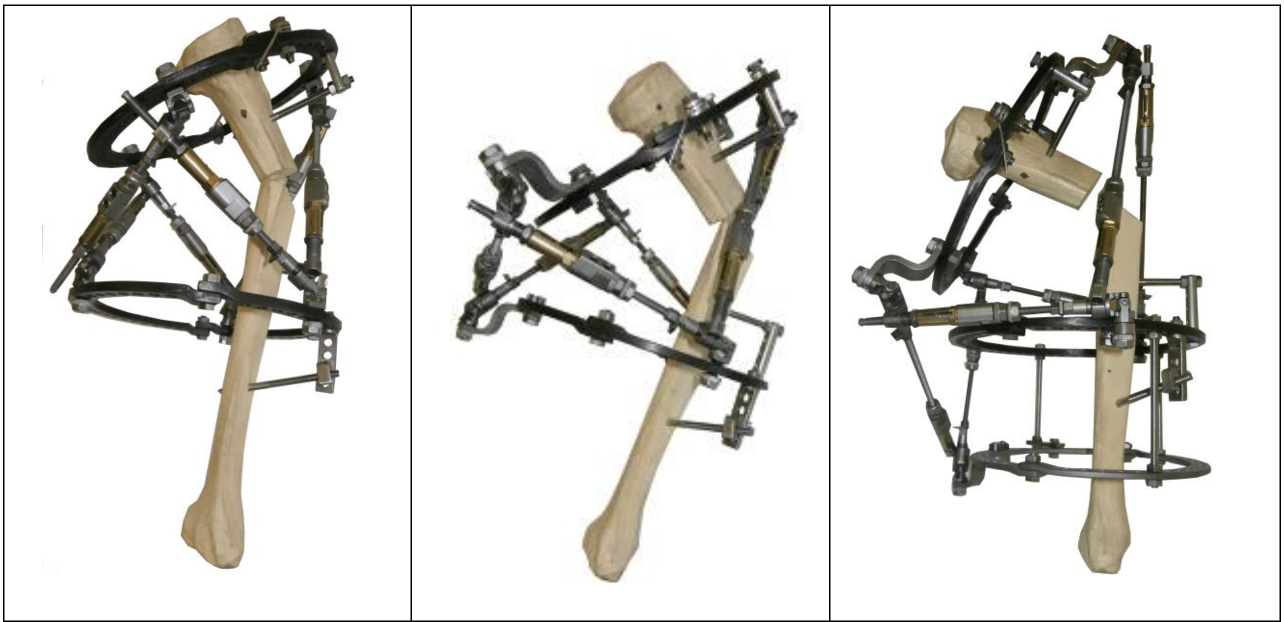
It’s better to make equal distance between the points of strut fixation to the ring to form equilateral triangle. But this requirement is not obligatory (Fig. 16).



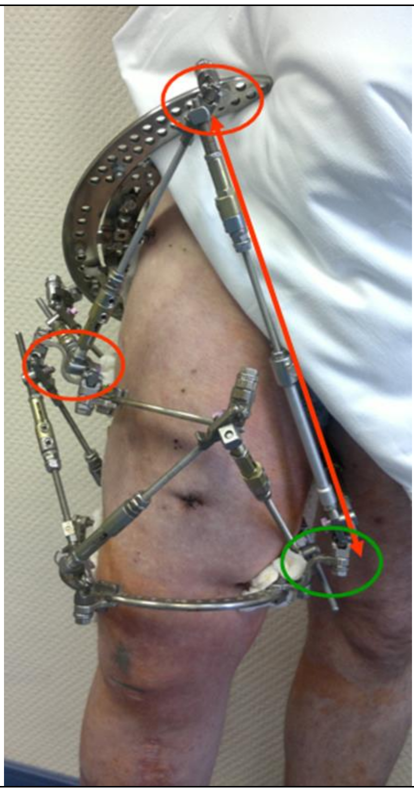
a	b

Fig. 16. Fixation of struts to support. **a** – making equilateral triangle. **b** – random fixation

If a distance between rings is too small, strut fixation is possible not only to the basic and the mobile supports, but to the stabilizing support as well. If the distance between supports is “too much”, length of strut can be increased by means of additional threaded or telescopic rods (Fig. 17).



a	b	c



d

Fig. 17. Abilities of Ortho-SUV Frame assembling. **a** - "standard" configuration: struts are fixed directly to the basic and mobile supports. **b** - distance between supports is not enough for strut fixation directly or using straight plates. Therefore Z-shaped plates are used. **c** - distance between support is not enough for strut fixation by means of Z-shaped plates. Therefore some struts are fixed to stabilizing support. **d** - increasing strut length with the help of telescopic rod

NB!

*At any mentioned variant of frame assembly two rules must be observed: “**Logo rule**” and “**Watch rule**”.*

1. “Logo rule”

A logotype “SUV” marked on the struts must be always directed externally (to the side opposite the bone) (Fig. 18).

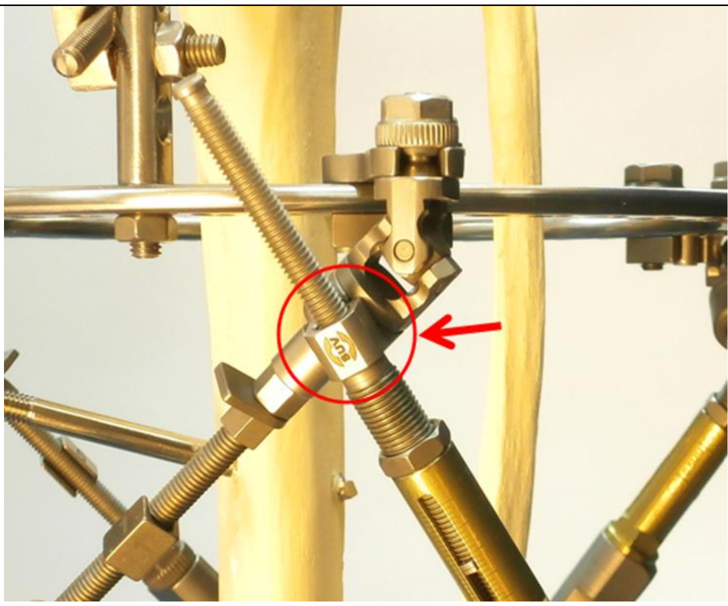
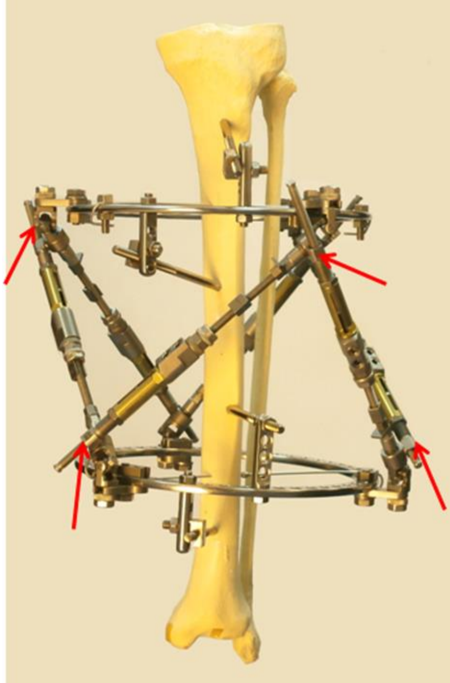
	
a	b

Fig. 18. “Logo rule”. **a,b** - logotype “SUV” marked on struts must be always directed externally (to the side opposite the bone)

2. «Watch rule»

The strut #1 must be always located on the left from the strut #2. At connection of the strut #2 to the strut #1 “logo rule” must be observed. The strut #1 is symbolized by the left arm wearing a watch. The strut #2 is symbolized by the right arm pointing (“covering”) the watch (Fig. 19).

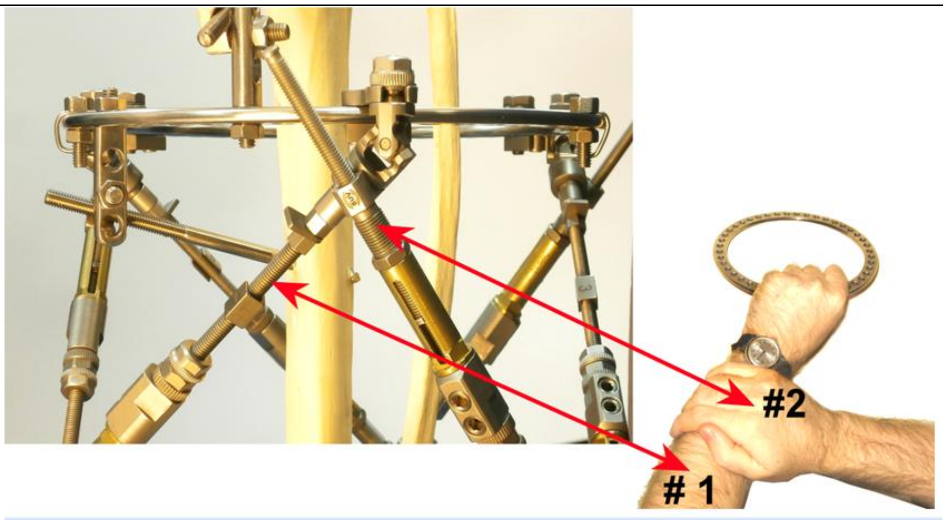
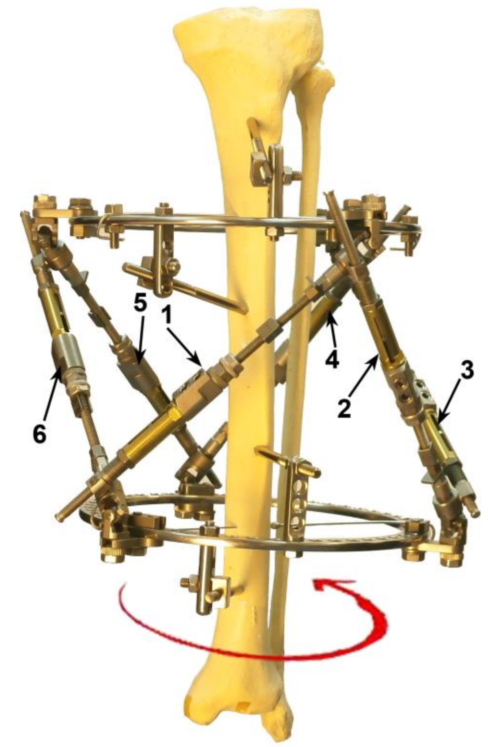


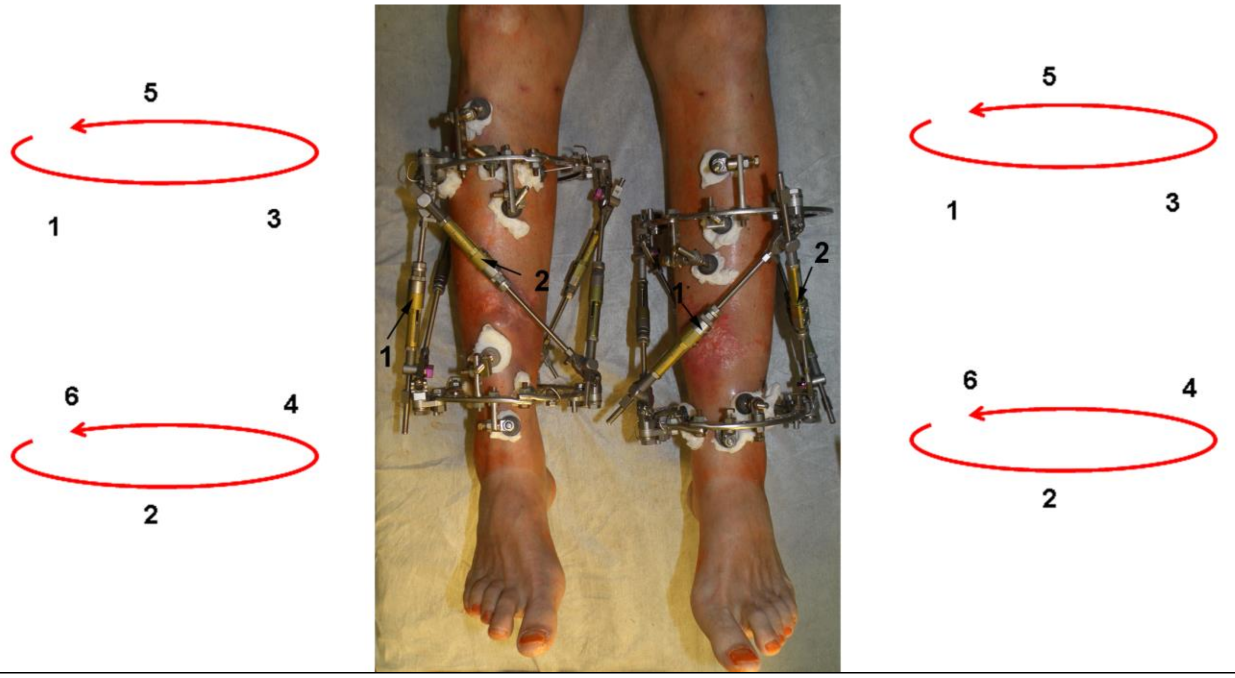
Fig. 19. The mnemonic “watch rule”. Strut #1 corresponds to left arm, i.e., arm that normally wears a watch. Strut #2 corresponds to right hand, pointing (covering) the watch

The positions of the struts #1 and #2 should always comply with this rule regardless of whether the frame is applied to the left or to the right limb. Further numbering is done counter-clockwise. Thus joints of struts

##1, 3 and 5 are fixed to the basic (proximal) support; joints of the struts ##2, 4 and 6 – to the mobile (distal) support (Fig. 20).



a

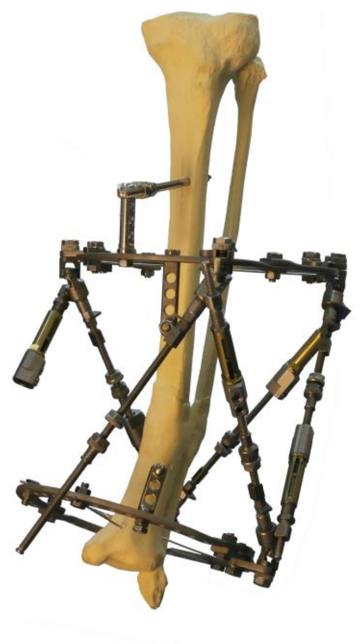
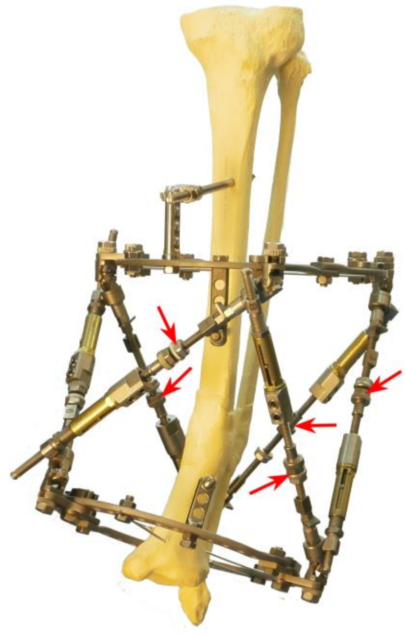


b

Fig. 20. Struts numeration. **a,b** - no matter which anatomic side is involved, the positioning of struts #1 and #2 must comply with the “watch rule” and made counter clock-wise. struts ##1, 3 and 5 are fixed to the basic (proximal) support; joints of the struts ##2, 4 and 6 – to the mobile (distal) support

The algorithm of Ortho-SUV Frame assembling is illustrated in Fig. 21. Note, that before strut connection, the screw #1 (Fig. 10a) must be loosed in order that connector nut (Fig. 10b) should have a possibility to be freely moved into the strut length changing unit.

	
a assembling proximal (basic) ring	b assembling distal (mobile) ring
	
c fixing strut #1 to basic ring	d insertion of threaded rods of strut #2 into strut length changing unit of strut #2 (it is fixed to the joint of strut #1). Fixing strut (joint) #2 to distal (mobile) ring

	
e insertion of threaded rods of strut #3 into strut length changing unit of strut #3 (it is fixed to the joint of strut #2). Fixing strut (joint) #3 to proximal (basic) ring	f insertion of threaded rods of strut #4 into strut length changing unit of strut #4 (it is fixed to the joint of strut #3). Fixing strut (joint) #4 to distal (mobile) ring
	
g insertion of threaded rods of strut #5 into strut length changing unit of strut #5 (it is fixed to the joint of strut #4). Fixing strut (joint) #5 to proximal (basic) ring	h insertion of threaded rods of strut #1 into strut length changing unit of strut #1 (it is fixed to the joint of strut #6). Fixing strut (joint) #6 to distal (mobile) ring. Note, that all connector nuts are at some distance from strut length changing unit (pointed by arrows)

	
i insertion of connector nuts into the body of strut length changing unit. Fixing screws #1. Stabilization of strut length changing units by lock-nuts	j at osteotomy struts ##1, 3 and 5 should be temporarily disconnected from proximal support

Fig. 21. Step-by-step Ortho-SUV Frame assembling

Hereby in Ortho-SUV Frame assembling:

- external supports of any shape and type, excluding monolateral and arch supports, can be used;
- supports can be placed at any random angle to bone fragments axis;
- the bone can be placed in the centre of support as well as eccentrically;
- struts can be fixed to supports directly as well as using straight or Z-shaped plates;
- the struts can be fixed not only to basic and mobile supports but also to stabilizing supports;
- the places of struts fixation to supports can be chosen by a surgeon randomly. It’s better to make equal distance between the points of fixation to form equilateral triangles. But this term is not obligatory;
- the strut length is formally not limited and depends on the length of threaded rods used.

None of these parameters requires additional and special data to be input in the software.

4. Modes of Ortho-SUV Frame operation

For practical reasons, the distal (mobile) support is moved relative to the proximal (static, basic) support. A length change of even one of the struts will cause the mobile support to dislocate in three planes. By changing the lengths of every strut, displacement of the mobile support over the required direction and distance is achieved. The amount of the length change for every strut is calculated by a computer program.

There are two modes of operation for an Ortho-SUV Frame:

1. «Fast struts» mode;
2. «Deformity correction» mode.

4.1 «Fast Struts» mode

This mode is used for acute fracture reduction or when deformity correction is implemented under visual control or fluoroscopy. The procedure starts with the loosening of the large lock-nuts, moving them, by their rotation, away from the strut length changing unit. Fixing screws #1 are loosened using the hexahedral screwdriver (Fig. 22a). The connector nuts are moved behind the lock-nuts (Fig. 22b). The next step is a reduction, implemented by manually moving the rings relative to one another (Fig. 22c). The connector nuts are then moved along the threaded rods until each one locks with its respective strut length changing unit. Fixing screws #1 are tightened (Fig. 22d). Finally each strut length changing units must be fixed by lock-nuts.

	
a	b

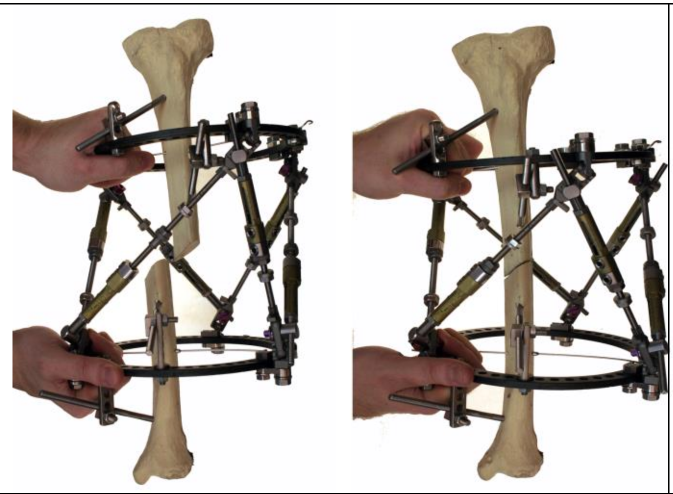
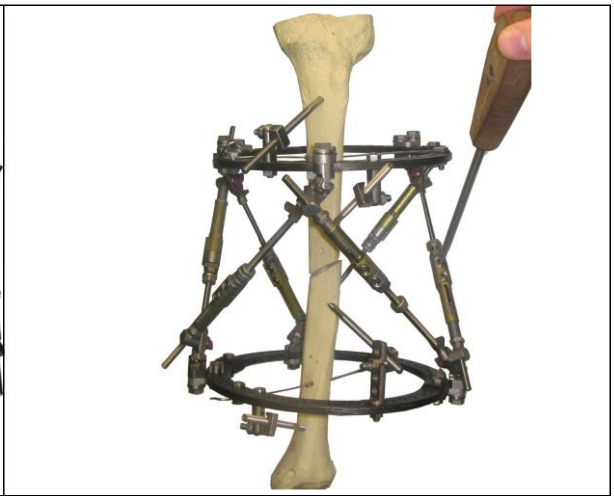
	
c	d

Fig. 22. Fracture reduction in fast strut mode. **a** – fixing screws #1 of all the struts are loosened. **b** – the connector nuts are moved along the threaded rods. **c** – acute reduction. **d** – the connector nuts are moved along the threaded rods until each one locks with its own strut length changing unit; the fixing screws #1 are tightened

4.2 «Deformity correction» mode

This mode is applicable when there are indications both for gradual deformity correction and fracture reduction. The computer program calculates which of struts is to be lengthened or shortened. The strut length changing unit is equipped with a scale. For a strut to be lengthened, the strut length indicator is set in its extreme "−" (minus) position. For a strut intended for shortening, the indicator is set in its extreme "+" (plus) position.

Procedure on moving the indicator in necessary position is named "*Strut adjustment*" or *"Reverse"*. To execute reverse procedure it is needed to do the following:

1. Loosen the lock-nuts.
2. Using the screwdriver loosen fixing screw #2 (Fig. 23a).
3. By opposing hand motions, rotate the body and the external cylinder of clutch of strut length changing unit in opposite directions (Fig. 23b). If the strut's length is minimal, the body of strut length changing unit is rotated clockwise; if it is maximal, rotation is counter-clockwise.
4. Tighten fixing screw #2 and the lock-nuts.

NB!

While reverse procedure the strut length does not change and the bone fragments are not displaced.

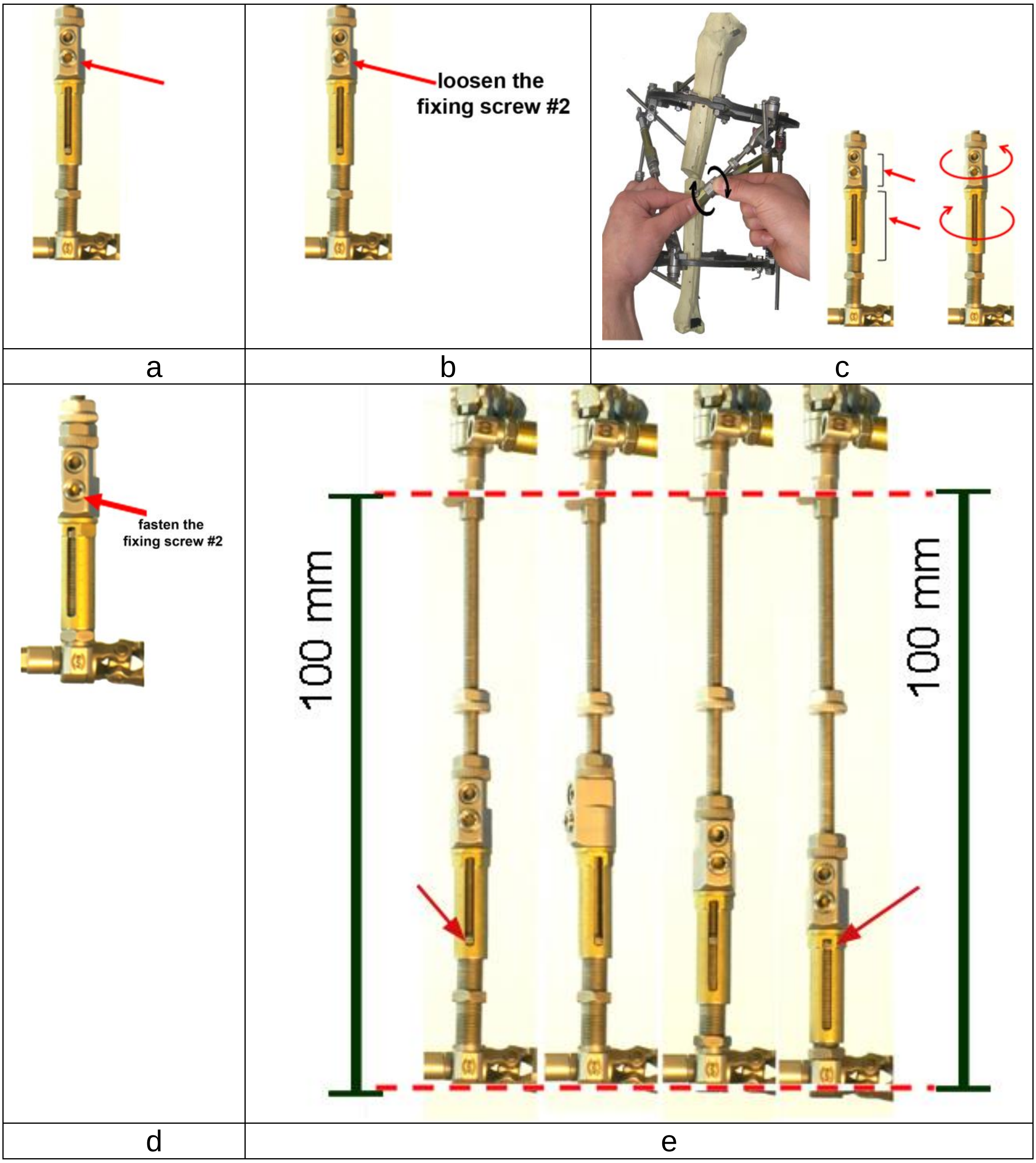
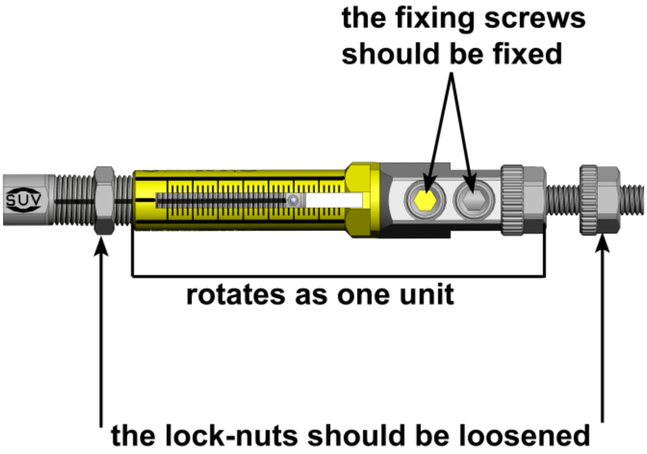


Fig. 23. Adjustment of a strut (reverse procedure). **a** – scale before the procedure: the indicator is set in its extreme «+» position. **b** – loosening fixing screw #2. **c** – the body and the external cylinder of clutch of strut length changing unit are counter-rotating. **d** – fixing screw #2 is tightened. **e** – the scale after the procedure: indicator is in its extreme «-» position. The strut length has not been changed!

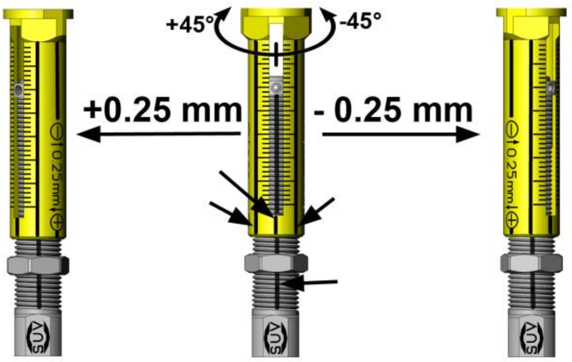
As it was already specified, the tightening of the screw #2 fixes the body to the clutch of strut length changing unit owing to what they rotate together.

To change strut length lock-nuts are loosened and the body with fix to it clutch are rotated (Fig. 24). As it was already mentioned, there are arrows "+" and "-" on the external cylinder of the clutch. Rotation of the body in the "+" direction increases strut length; rotation in "-" direction results in shortening of strut. Full turn of the body (360 deg.) changes strut length up to **2 mm**. The scale interval is 2 mm. Accordingly, 45 deg. turn changes strut length to 0.25 mm. To control gradual, 0.25 mm, change of strut length, there are eight longitudinal lines on the external cylinder and one longitudinal line on the internal cylinder. Turn from one line up to the next line corresponds the turn of the body by 45 deg., and, accordingly, change of strut length by 0.25 mm.

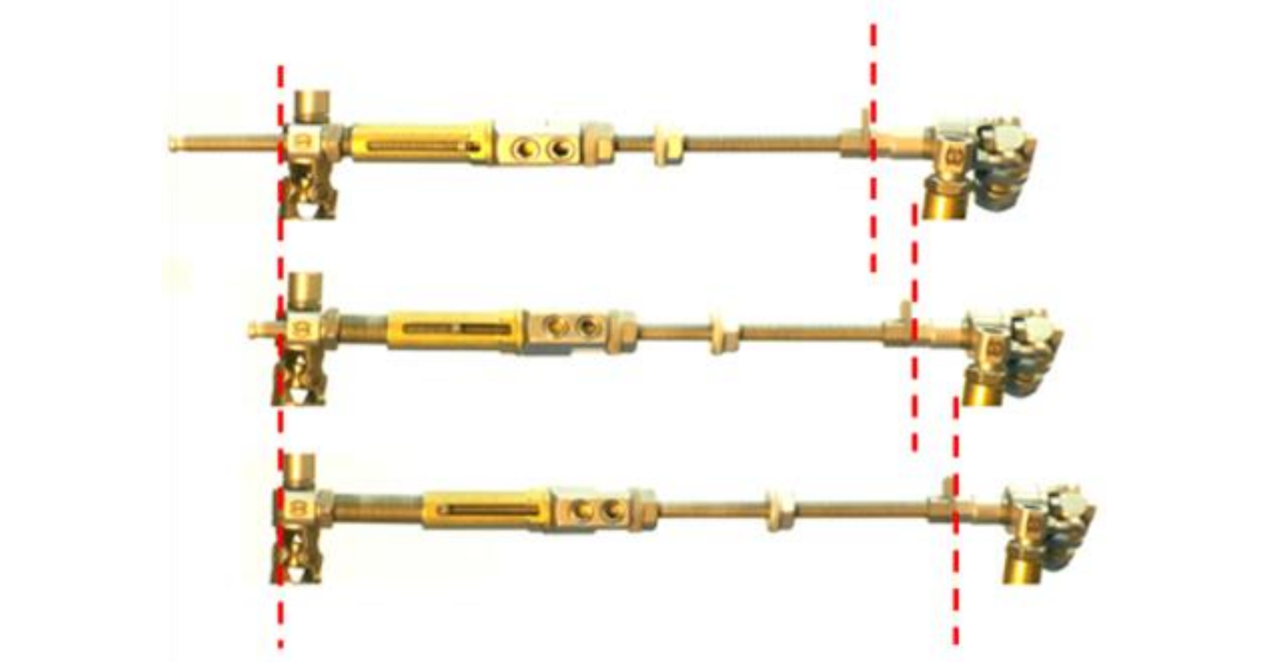
After changing length of strut body and clutch must be stabilized by lock-nuts.



a



b



c

d

e

Fig. 24. “Deformity correction” mode: gradual changing length of strut. **a –** loosing of lock-nuts. **b** - rotation of the strut length changing unit in "+" direction leads to strut lengthening; in "-" direction leads to strut shortening. Turn “from line to line” changes length of strut by ***0.25 mm***. **c** - full turn (360 deg.) of strut length changing unit changes strut length by 2 mm. The scale interval is 2 mm. **d –** strut is rotated by hand or, at strut tension, by spanner 12 mm. **e –** fixing of lock-nuts.

NB!

Sometimes the scale length is not sufficient for a fragment displacement to be corrected completely. In such cases the reverse *procedure (Fig. 23) must be repeated. Thus, the maximal strut length is limited only by length of threaded rod used.*

NB!

There are no situations when both fixing screws (#1 and #2) are loosened at the same time. The loosing of the screw #1 allows “fast strut” mode to be completed. The loosing of the screw #2 is necessary for “reverse procedure”. At gradual deformity correction both screws must be tightened.

The precisely controlled relocation of bone fragments requires that the amount of length change be calculated for every strut. This can be done using specialized software.

5. Software for the Ortho-SUV Frame

5.1 General information

The program for working with the Ortho-SUV Frame was written using the language “C++ Builder.” Its volume is about 1.400 kb. To install the program, copy the executable file onto a hard disc. The minimal requirements are: IBM PC-compatibility, operating system Windows 2000, XP or Vista, processor with a minimal quality of the DX486 and a minimum frequency of 1.5 GHz, and a memory of 256 Mb RAM. Installation requires at least 10 Mb of disk space. Color display with a minimal resolution of 800 x 600 pixels is necessary.

Software is available as a folder “SUV-Software vp. ******”. There is a number of the version of the program instead of "*******", for example, “SUV-Software vp. 1.0”. The folder has two files: “SUV-Software vp.exe” and "winspool.dll". The later version has greater number, than the previous one. Updated software is placed on website http://ortho-suv.org.

Program works with digital roentgenograms saved in formats .bmp and .jpg. The software is protected from non-authorized use by HASP-key (Fig. 25). The HASP-key as an USB-charm is included into the complete set of Ortho-SUV Frame. The appropriate HASP-driver should be installed on a computer. The driver can be taken from the website http://www.aladdin-rd.ru/support/downloads/haspsrm/. It is necessary to download and install the driver “Sentinel HASP for Windows. Version 6.22 (the interface: GUI)”.

Before start your first work with the program, please, follow few essential steps described in Appendix 1.

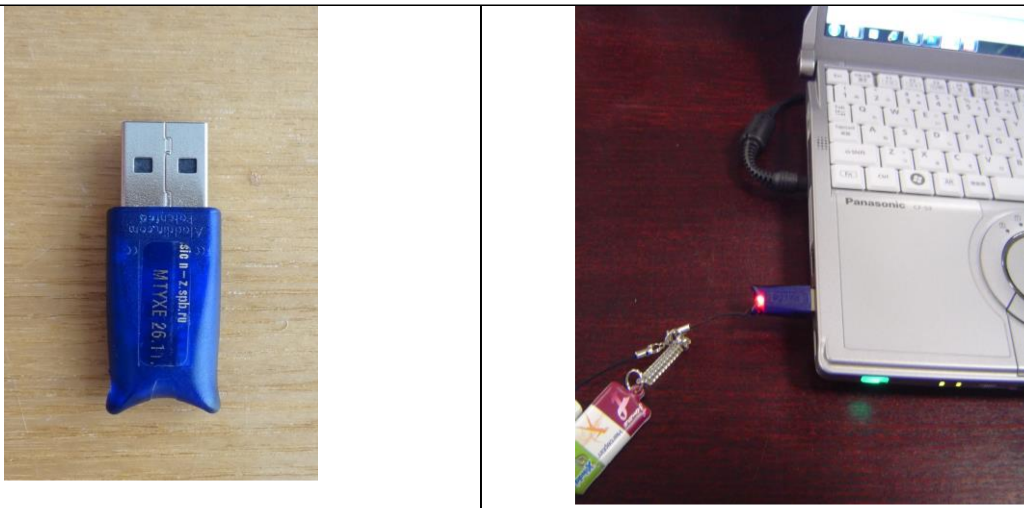


Fig. 25. Before software use the HASP-key must be inserted into USB-port of a computer. The red indicator confirms, that the program is ready to work

Working with the program involves advancing through its sequence of 13 steps. At every step, if necessary, the operator can return to the previous one. If the obligatory actions required at every given step are not performed, moving to the next step is not possible.

5.2 The parameters must be input into the software

Two groups of parameters must be input into the computer program:

Group 1. Parameters, measured on the frame (12 parameters) and at making roentgenograms (2 parameters);

Group 2. The parameters determined on roentgenograms (14 parameters).

The first group of parameters can be taken using measuring tools. Parameters of the second group are found using tools of the software.

5.2.1 Parameters, measured on the frame

The 12 parameters measured on the frame are *strut length* (6 parameters) and the *side lengths of the triangles* (6 parameters) whose apexes are the centers of the nuts fixing the strut joints to the ring or plate.

Strut length is a distance between the hook located on joint and the end of the strut length changing unit (Fig. 26). It is a mistake to measure the distance from the hook up to the end of the threaded rod!

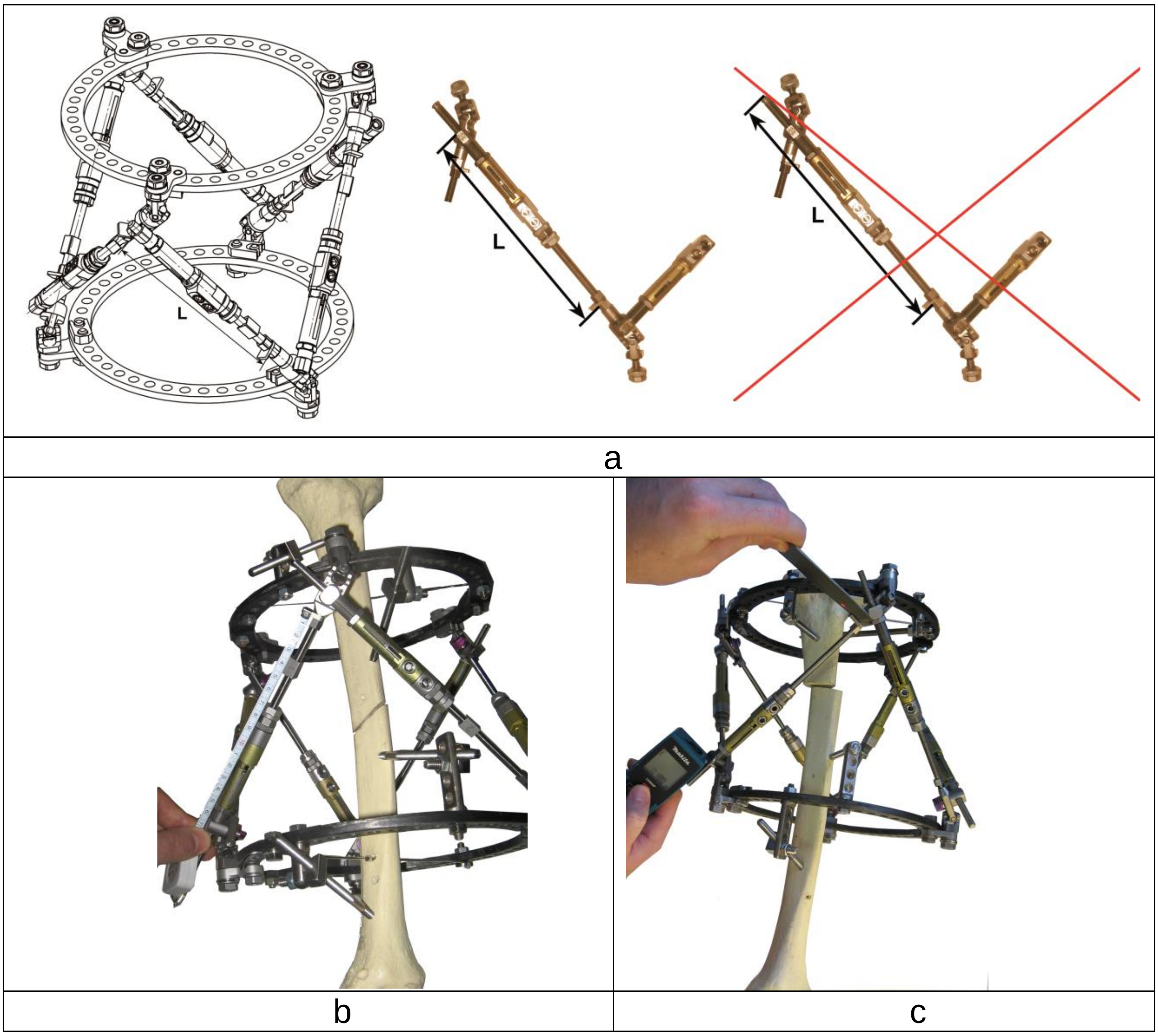
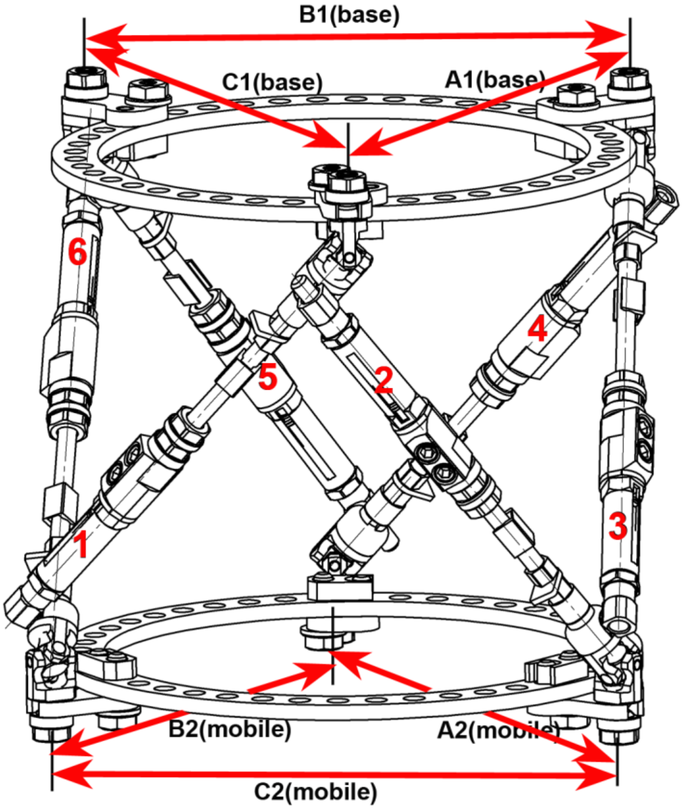


Fig. 26. Strut lengths measurement. **a** – strut length “L” is measured between strut hook and ending point of strut length changing unit. It is a mistake to measure distance from hook up to end of threaded rod! **b** – measurement using a ruler or measuring tape. **c** – measurement by laser range-finder

The sides of the triangles are measured between the centers of the nuts that fix the joints to the rings or to the plates (Fig. 27). It is erroneous to measure the distances between the centers of the nuts that fix the plates to the rings!

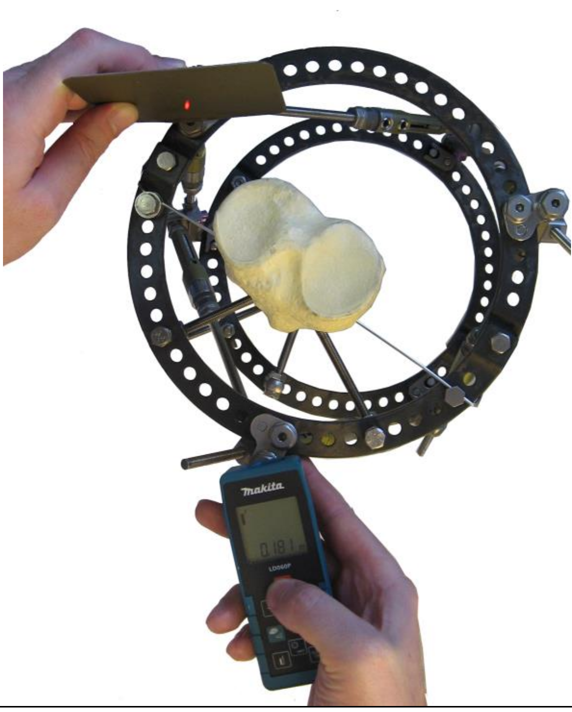
For the basic ring, the sides of the triangle are indicated as A1 (Base), B1 (Base), C1 (Base). Thus, A1 (Base) is the distance between joints #1 and #3; B1 (Base) is between joints #3 and #5; and C1 (Base) is between joints #5 and #1.

For the mobile ring, the sides of the triangle are indicated as A2 (Mobile), B2 (Mobile), C2 (Mobile). Thus, A2 (Mobile) is the distance between joints #2 and #4; B2 (Mobile) is between joints #4 and #6; and C2 (Mobile) is between joints #6 and #2. All measurements are made using the special measuring tool (Fig. 27).



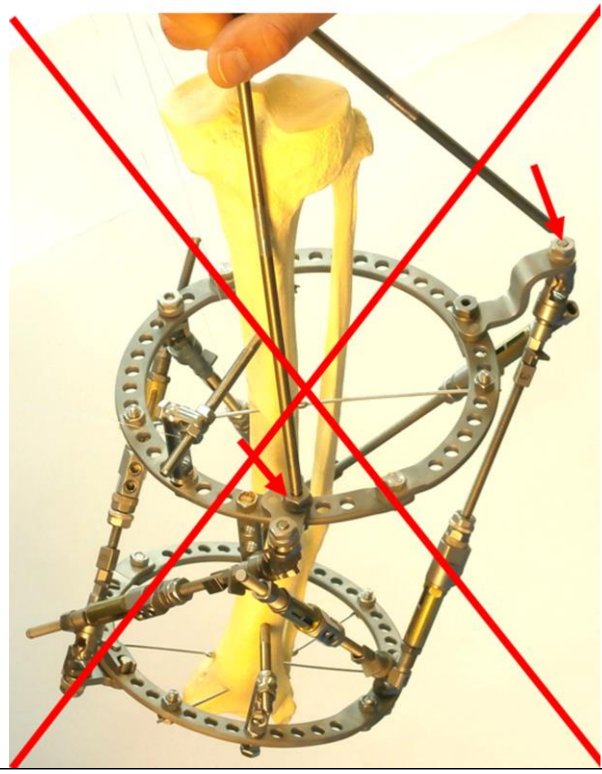
a

b



c

d



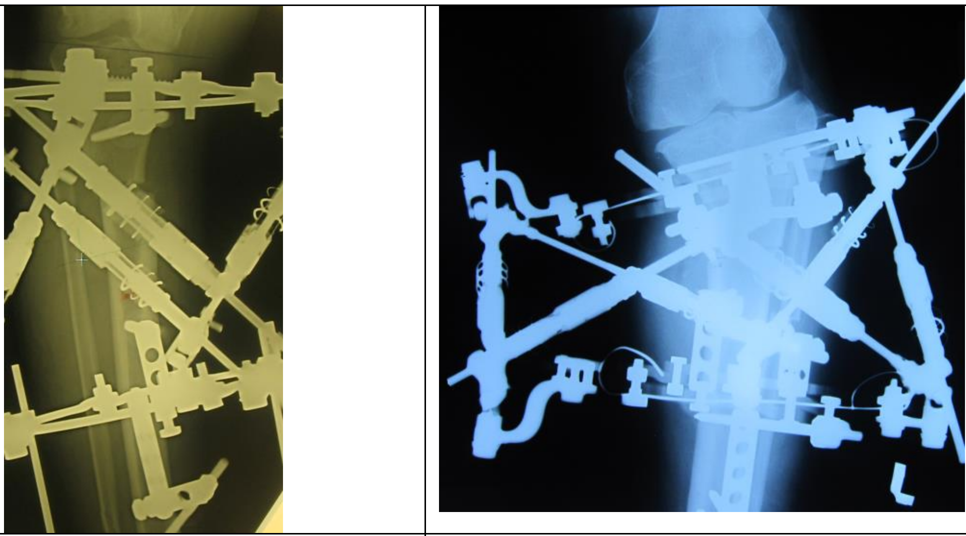
e

Fig. 27. Measuring sides of triangles. **a** – sides of triangles are measured between the centers of nuts that fix the joints to rings or to plates. **b** – measurement using special tool (triangular measurement device). Note, that one of strut is fixed directly to ring, and the second - with the help of plate. **c** – measurement using a laser range-finder. **d** – in this case distance between the centres of nuts fixing plates to ring is measured. It is a mistake! **e** - in this case the distance between the centre of nut fixing plate of strut #1 and the centre of nut fixing joint #3 to plate is measured. This is wrong measurement!

5.2.2 Parameters measured on X-ray

When roentgenograms are intended for the finding of the above-noted parameters, not only the standard rules [Paley D., 2005; Solomin L., 2013] but also the following must be observed:

1. The image field has to cover as many joints and struts as possible. Therefore film-cassette <30 cm in width are inappropriate (Fig. 28). The image field should contain only the helpful information. Edges of roentgenograms which do not have the necessary information, should be "to cut off" using any graphic editor.



a	b

Fig. 28. Image field. **a** – when a narrow film is used, the number of struts and joints visualized will be insufficient to measure necessary parameters. **b** – image field encompassing most of the struts and joints

2. For an opportunity of scaling (software steps 4 and 5) in the image field the ruler (Fig. 29) should be placed. It is placed directly on the film cassette (not in a projection of the centre of a bone!). If the film is placed into film-cassette holder, the ruler should be placed on a surface of a radiological table. For maintenance of necessary accuracy of scaling, the length of a ruler should not be less than 80 mm. Instead of the ruler it is possible to use any roentgen-visible subject of known (not less than 80 mm) lengths.

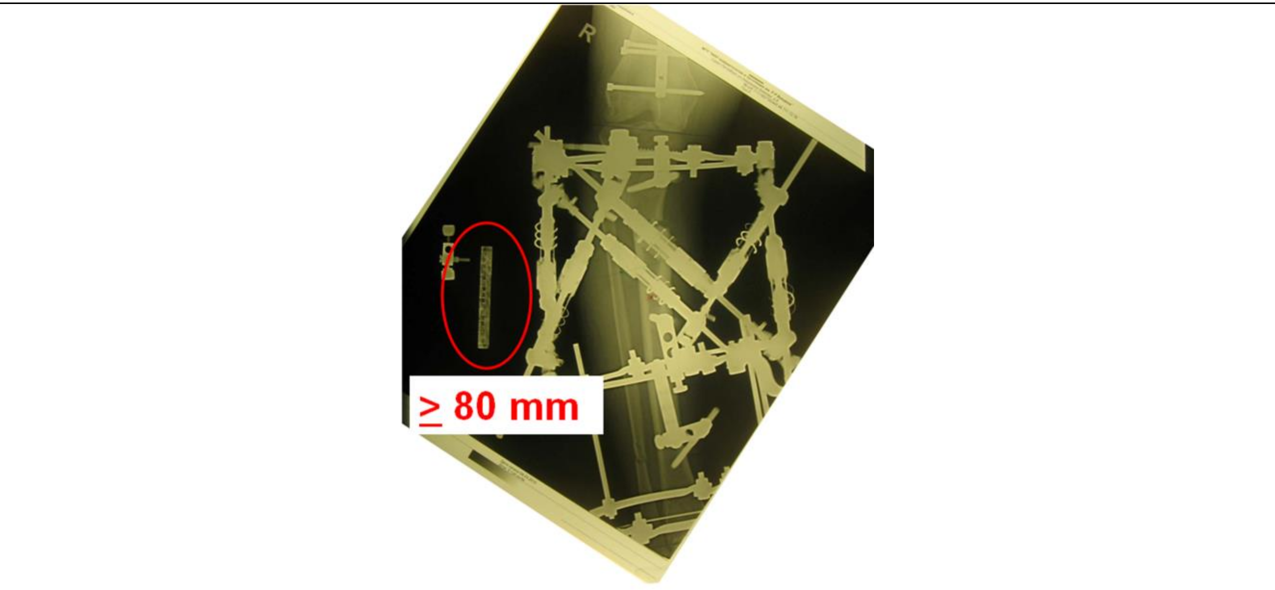


Fig. 29. For an opportunity of scaling the image field must contain roentgen-visible ruler with length not less than 80 mm. Ruler should be placed directly on the film-cassette or (if film-cassette holder is used) - on a surface of a radiological table

3. *Focal distance* must be measured. Focal distance is a distance in millimeters between anode of the X-ray tube and the film cassette. X-ray equipment often has focal distance sensors or measuring tape (Fig. 30).

NB!

When a radiopaque ruler is used (for scaling – step 4 in the program), a focal distance is measured between anode and the ruler. Therefore, if the ruler is placed directly on the film-cassette, the general rule works. But when the film-cassette is placed into the radiological table holder and the ruler is positioned on the surface of the X-ray table, the distance from anode to the ruler is taken as a focal distance. It is a mistake to measure the distance from anode to the center of a bone and placing the ruler on the bone level.

Fig. 30 Measuring focal distance (two parameters: for AP and Lateral views)

4. X-ray *beam center* must be indicated on the roentgenogram. For this purpose, a small (about of a cent coin in size), usually cross-shaped marker is placed on film-cassette, where is the center of X-ray beam (Fig. 31). While X-ray examining, make sure that this beam center marker did not overlap with any radiopaque parts of the frame, such as struts or rings.

a	b

Fig. 31. Beam center identification. **a** – self-adhesive X-ray-positive mark to visualize the beam center. **b** – this mark points the beam center on the film

5. To facilitate the strut number identification, special radiopaque markers with bar-codes are used (Fig. 32).

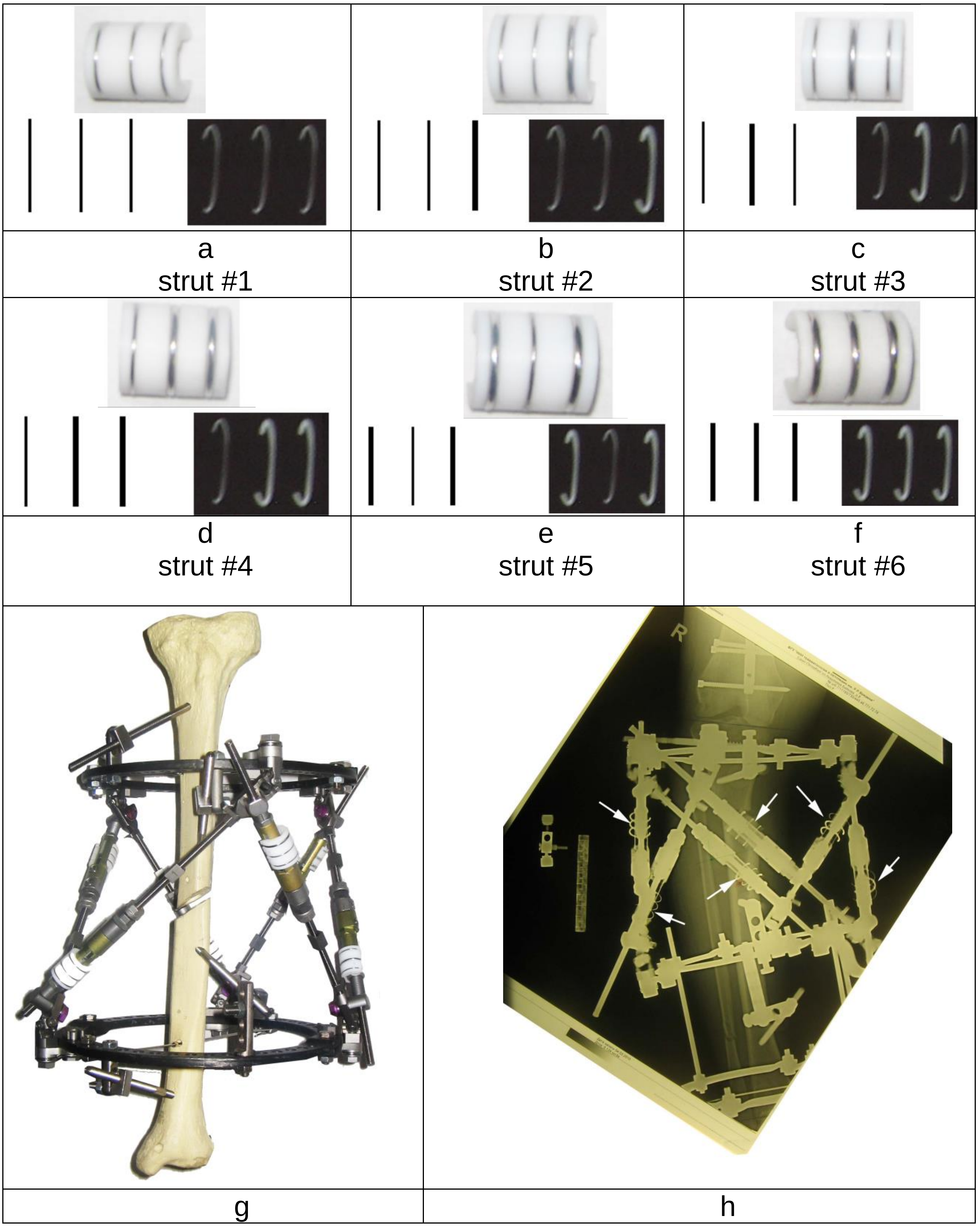


Fig. 32. Strut markers. **a-f** – markers of struts ##1-6, schemes and image of "bar-codes" on roentgenogram. **g –** strut markers are fixed on struts. **h** - x-ray image of strut markers (pointed by arrows)

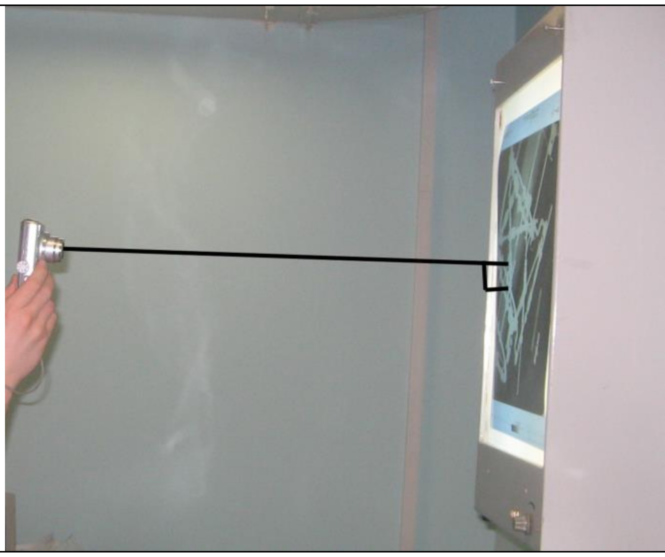
6. In some cases it is impossible to make AP and lateral views in tangential projections (perpendicular to each other). For Ortho-SUV

software AP and lateral views made at the angle *not less* than 45º can be used.

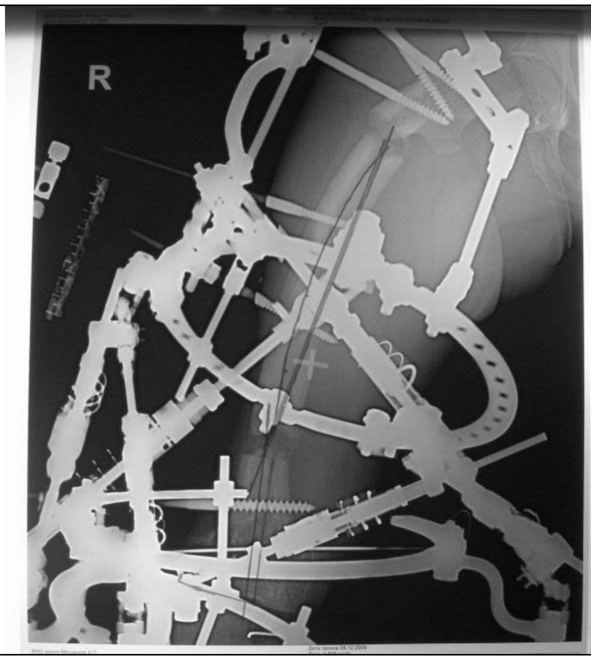
7. If there are analog X-rays, they must be converted into digital form, for example, by photographing. Camera should be located parallel to X-ray view box and the X-ray image should be taken completely (Fig. 33).

NB!

The distance from the camera up to the X-ray view box is not "the focal distance". The focal distance which was at X-ray examination should be input into software.



a



b

Fig. 33. Converting analog X-rays into digital format. **a** – camera should be located parallel to X-ray view box. It is not "the focal distance"! **b** – image includes struts, joints, scaling ruler and marker of beam center

5.3 Working With the Program

After an initial training, including 10-12 calculations, the program assumes the following standard of work:

- 8-12 minutes in case of fractures and shaft deformities;
- 12-15 minutes in case of epimetaphyseal deformities and reconstruction surgeries.

It is necessary to provide maximum accuracy of each parameters input (Steps 1,6,7,10 and 11) and proper performance of the procedures required (Steps 4-10 and 12). It will provide "ideal" reduction and deformity correction.

NB!

The folder "Ortho-SUV Frame" must be created on the working table of the computer. This folder should contain folders "SUV-Software" (for files of the software) and "Cases" (for clinical cases).

Before working with the program it is necessary to create a folder with the title of the clinical case, for example "Case 1". AP and lateral view of the patient must be placed in this folder (Fig. 34).

Fig. 34. The clinical case folder should contain patient's AP and lateral view

To start working, double-click "SUV.exe" file. Program window appears. Press the "New document" button. New document will be created with its first page entitled «**Step 1**» (Fig. 35).

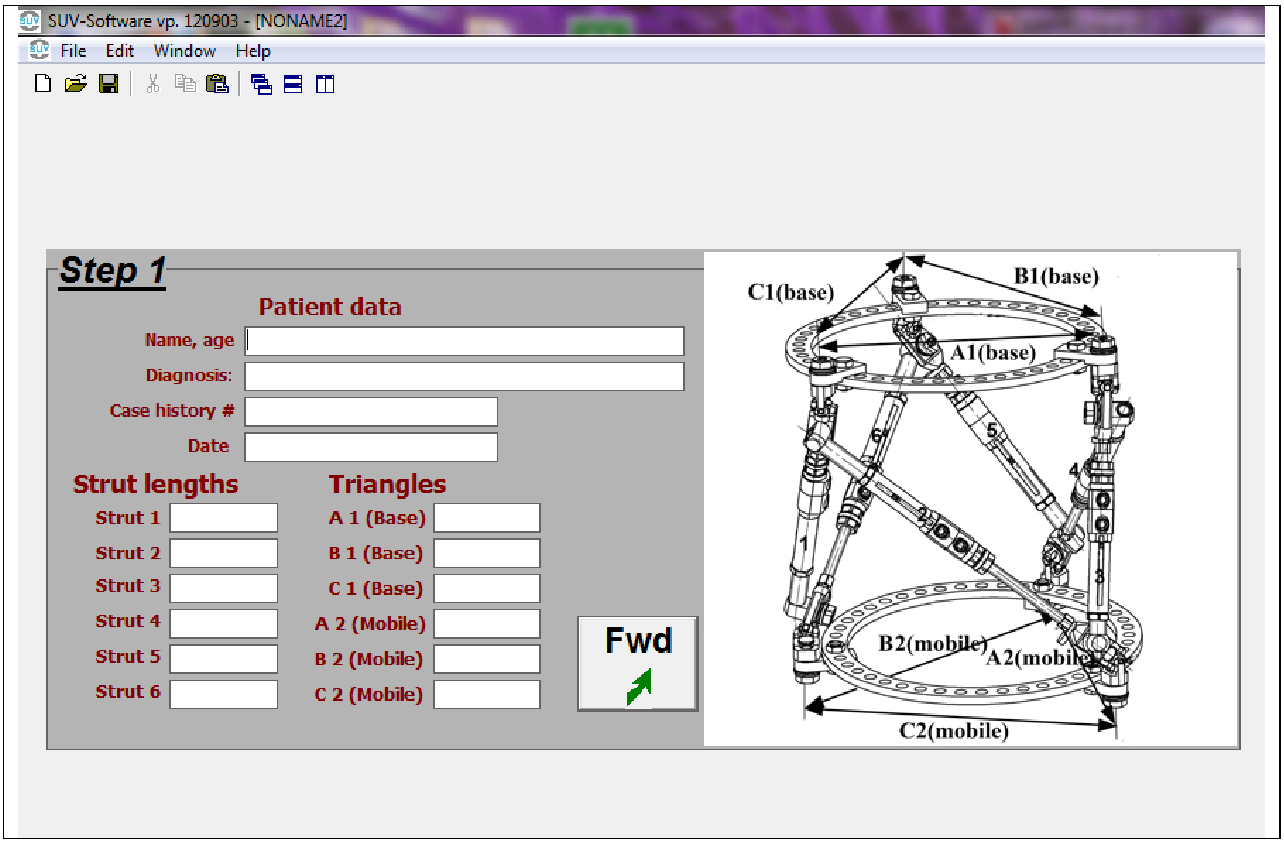


Fig. 35. Program window step 1 after new document has been created

NB!

After "clinical case" file had been created, it must be saved in the same folder where patient's AP and lateral view are placed (Fig. 36). This file should be saved after passing each step of the software.

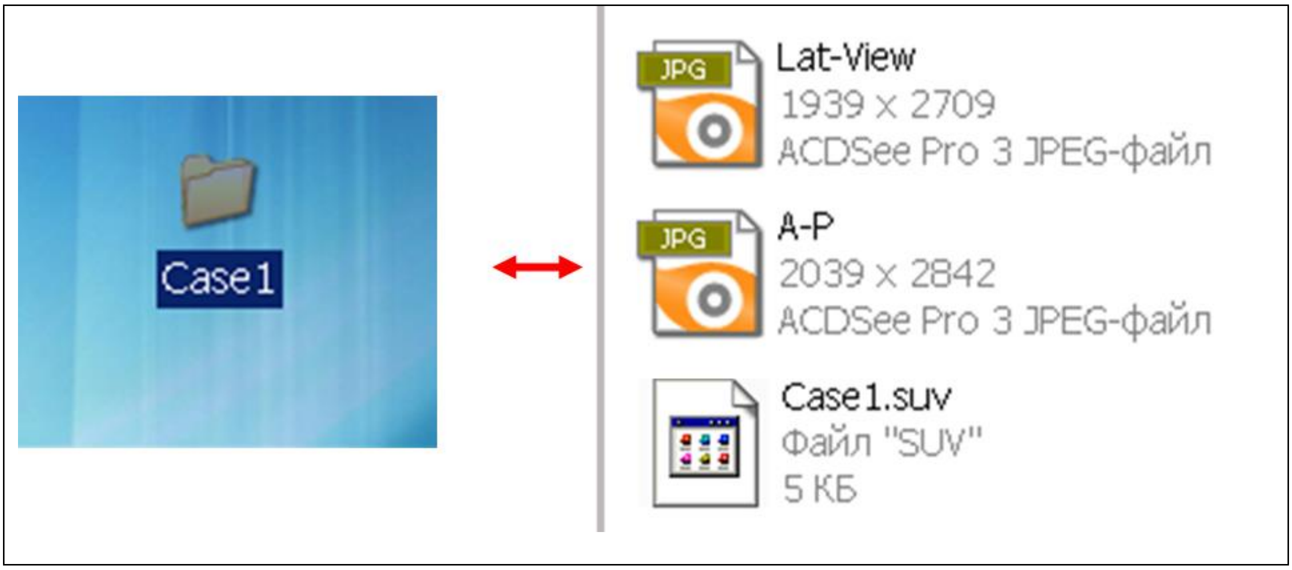


Fig. 36. Clinical case folder must contain patient's AP and Lat view as well as SUV-file created by the software

NB!

If for some reason difficulties have occurred (usually associated with incorrect usage), sent the folder contained X-rays and SUV-file to the following email address: orthosuv@gmail.com. In the accompanying message, explain in detail the problem that has been encountered. To resume working, it is usually enough to re-start the program and, obviously, avoid one's previous mistakes.

Step 1: Input of Strut Lengths and Those of the Sides of the Triangles

Fill in the window "Patient data" by typing in the patient's surname, name, age, and diagnosis as well as the modeling date (Fig. 37).

Fill in the fields "Strut 1–Strut 6" (Fig. 37) by inserting the lengths of the corresponding struts, as measured according to the rules described in Sect. 5.1 (Fig. 26).

Fill in the fields "Triangles A1 (Base), B1 (Base), C1 (Base), A2 (Mobile), B2 (Mobile), C2 (Mobile)" by typing in the respective sizes of the sides of the triangles whose apexes are the centers of the nuts fixing the strut joints to supports or to plates. The rules for measuring the sides of the triangles are provided in Sect. 5.1 (Fig. 27). There are scheme-prompt at this step window.

After completion of these fields and saving the file, click on the "Forward" button and continue to the next step.

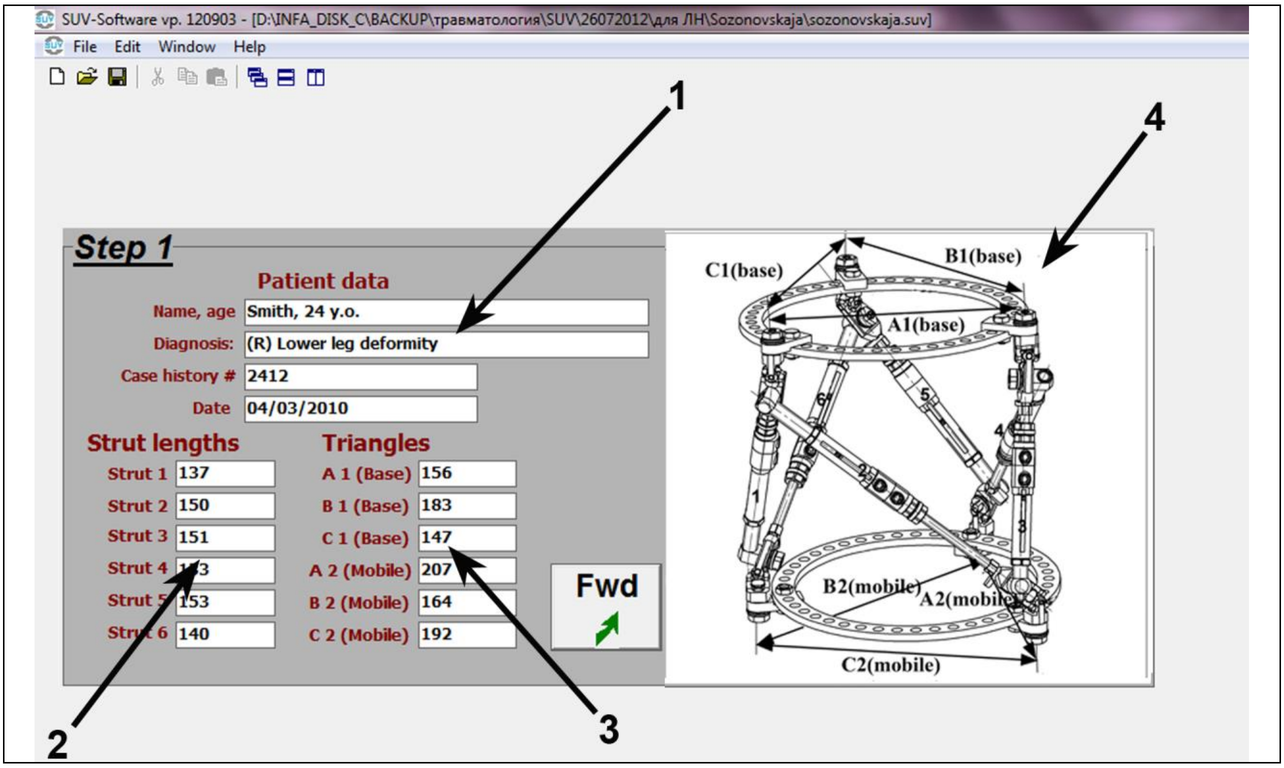


Fig. 37. Data input in Step 1. 1 – patient data; 2 – strut lengths; 3 – triangle side lengths; 4 - scheme-prompt

Step 2: Uploading the AP Roentgenogram

A movable panel appears with a button to load the AP roentgenogram: "AP view" (Fig. 38).

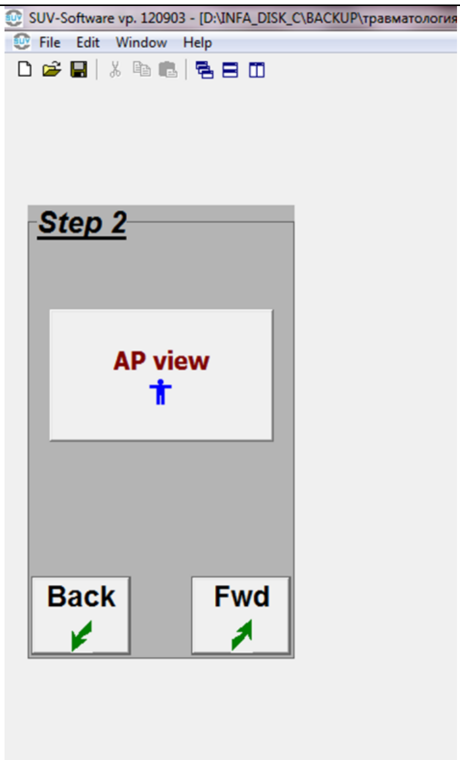


Fig. 38. Ortho-SUV program window in Step 2: Uploading the AP view

To upload the AP roentgenogram, click on the button "AP view." A drop-down menu appears. Using the "browse" function, choose the previously prepared AP roentgenogram. Click on the button "Open." At this point, the operator is returned to Step 2. Note that the AP view itself *does not appear*. Click on the "Forward" button and continue to the next step.

Step 3: Uploading the Lateral (profile) Roentgenogram

To upload the lateral digital roentgenogram, click on the button "Lateral" (Fig. 39). A drop-down menu appears. Using the "browse" function, choose the previously prepared lateral roentgenogram. Click on the "Open" button. Two radiographic images will appear in the document window: the AP view to the left and the lateral view to the right (Fig. 40).

After these two views appear, save the file, click on the "Forward" button and continue to the next step.

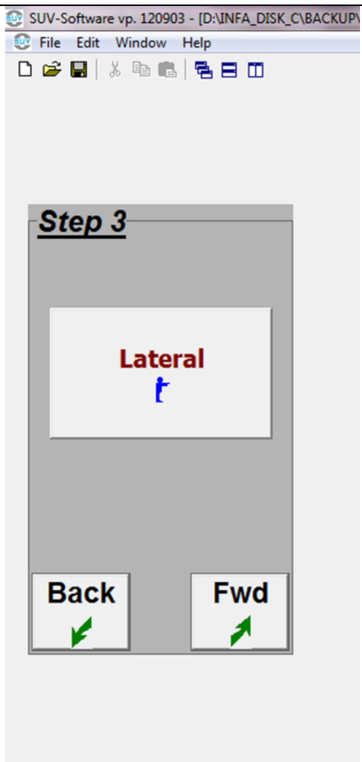


Fig. 39. Ortho-SUV software window after Step 3

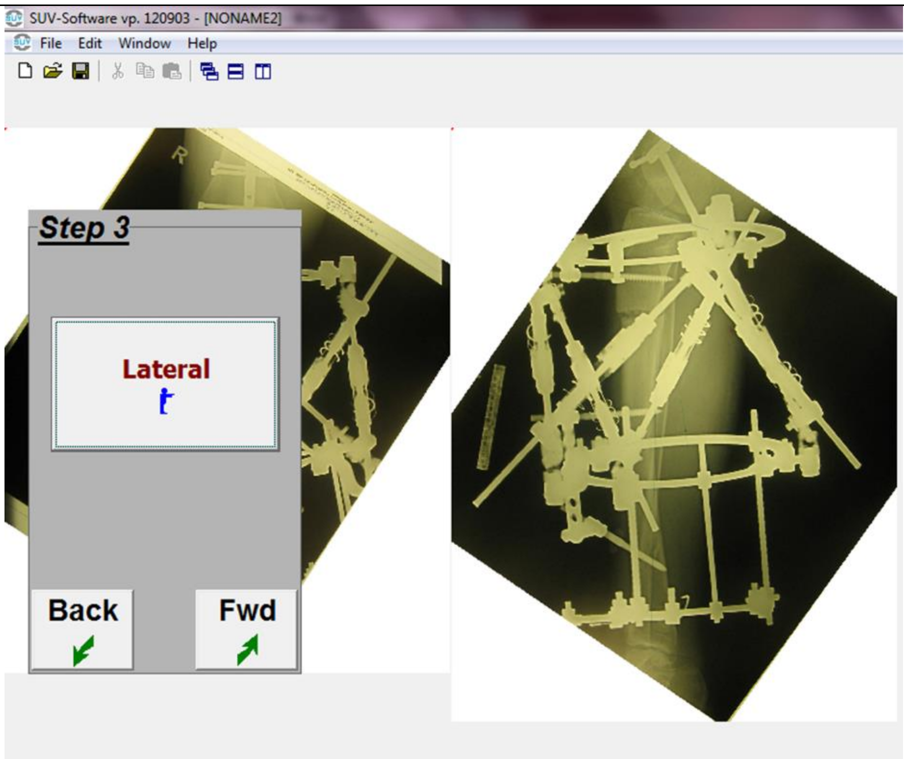


Fig. 40. Ortho-SUV software window after Step 3, in which the AP and lateral views appear

Step 4: Scaling of the AP View

At the step 4 in a window of the program appear earlier uploaded AP view, the button “+/-” (“zoom in/zoom out”) and the special tool, so-called "dumbbell" (Fig. 41). Having pressed by the button “+/-”, the user chooses, what he wants to make with the roentgenogram: magnification or reduce the image. Thus near "+" or "-" appears an appropriate dot index. After that double click of the left button of the mouse in the field of the roentgenogram, the user enlarges or reduces the image. The picture is enlarged (reduced) around of the cursor. It lets make the centre for magnification (demagnification) any point of the roentgenogram. *Moving of the roentgenogram* along the screen is carried out as follows: having pressed on the left button of the mouse in a field of the roentgenogram and not releasing the mouse button, the user moves the cursor in that direction where he wants to move the picture.

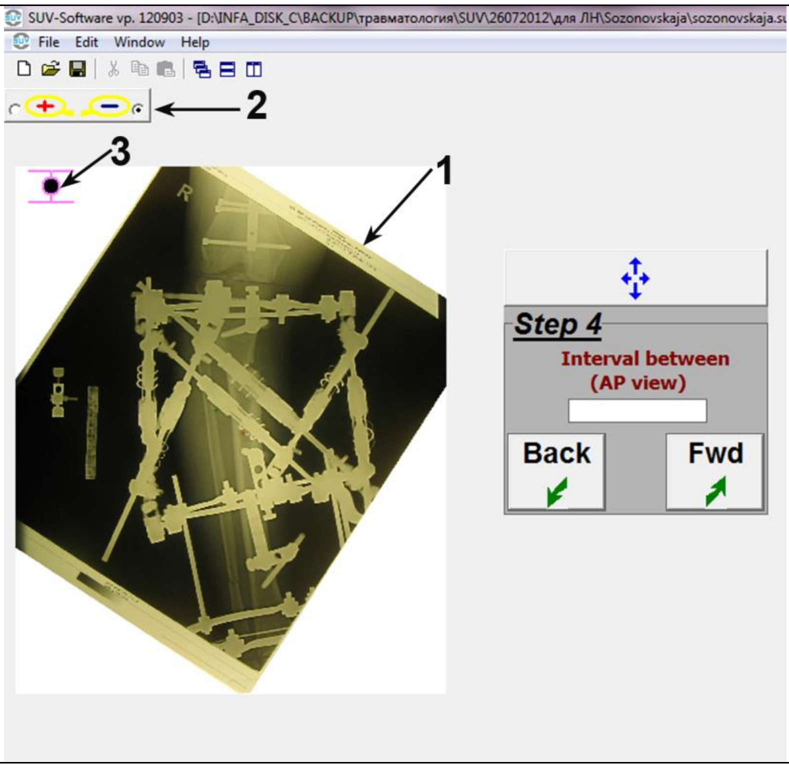


Fig. 41. Ortho-SUV software window in Step 4. 1 - AP view; 2 - “+/-” (“zoom in/zoom out”) button; 3 - tool "dumbbell"

For *scaling* the AP view, extreme points of the "dumbbell" must be overlapped with roentgen-visible ruler which is on the roentgenogram (Fig. 29). To move the "dumbbell", place the cursor directly on its center (visible as a small circle) and, while left-clicking the mouse, move the ruler around the display to roentgen-visible ruler. After that one of the ends of the "dumbbell" should be overlapped with one of the ends of the ruler. For this purpose direct the cursor on one of the ends of the "dumbbell" and, while left-clicking the mouse, drag it on screen before it coincides to the end of the ruler.

Due to this, the "dumbbell" is increased in length. Similarly overlap other end of the “dumbbell” with the opposite end of the ruler. After the length and position of the "dumbbell" have been set, fill in the field “Interval between (AP view)" by typing in the length of the known interval in mm (Fig. 42); then click on the "Forward" button to continue to the next step.

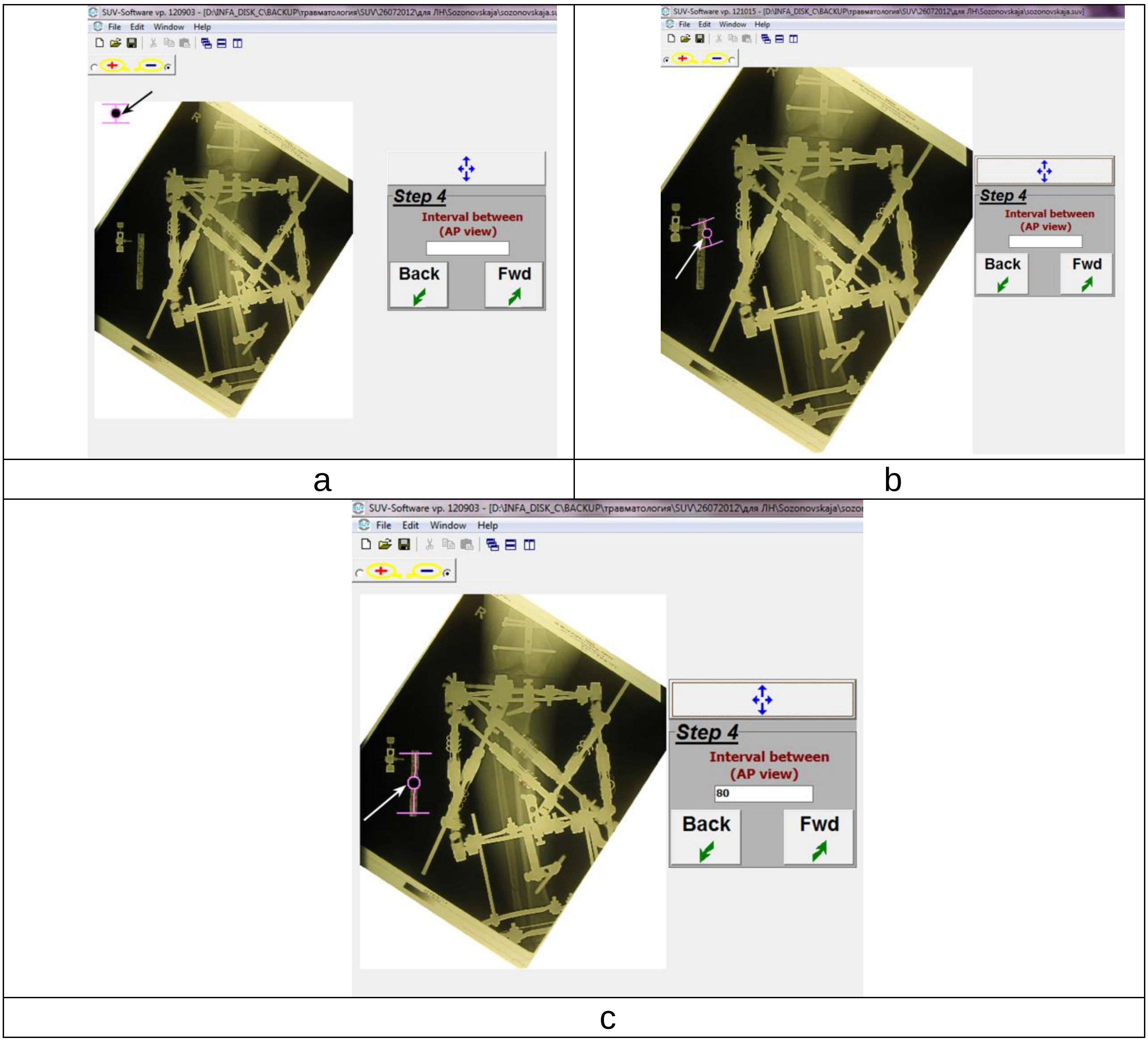
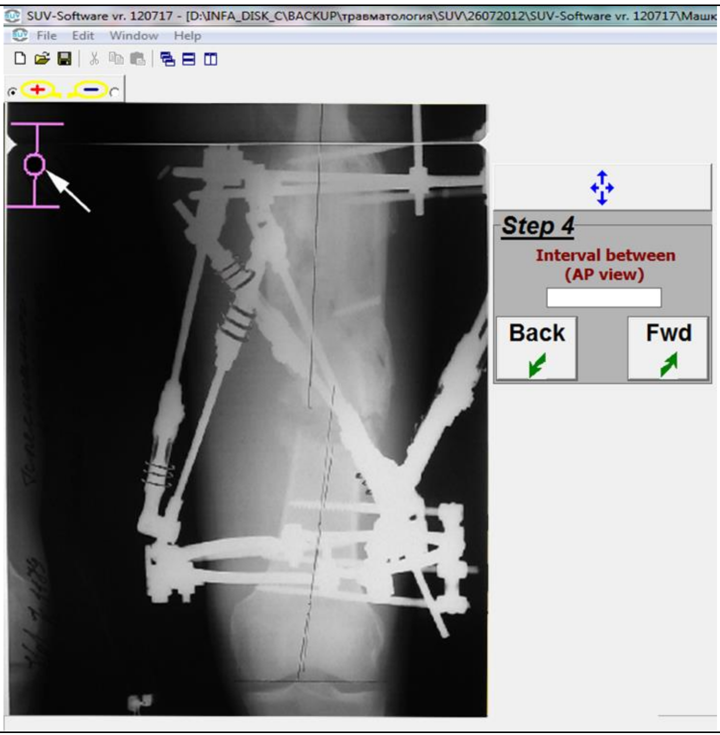
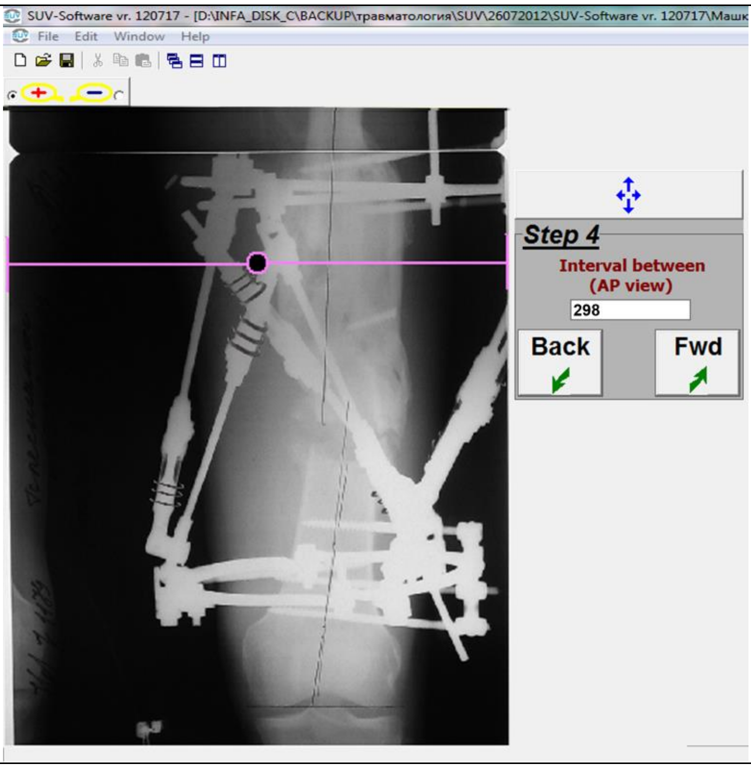


Fig. 42. Ortho-SUV software window in Step 4: «Scaling of AP view». **a** – prior to scaling. "Dumbbell" is outside of field of roentgenogram. **b** – "dumbbell" is moved to ruler, one of its ends is overlapped with ruler. **c** – after scaling. Both ends of "dumbbell" are overlapped with ruler. Field "Interval between" is filled in according length of ruler - 80 mm

If for the program the analog roentgenogram was photographed, for scaling the size of the roentgenogram can be used: its width or length (Fig. 43).



a

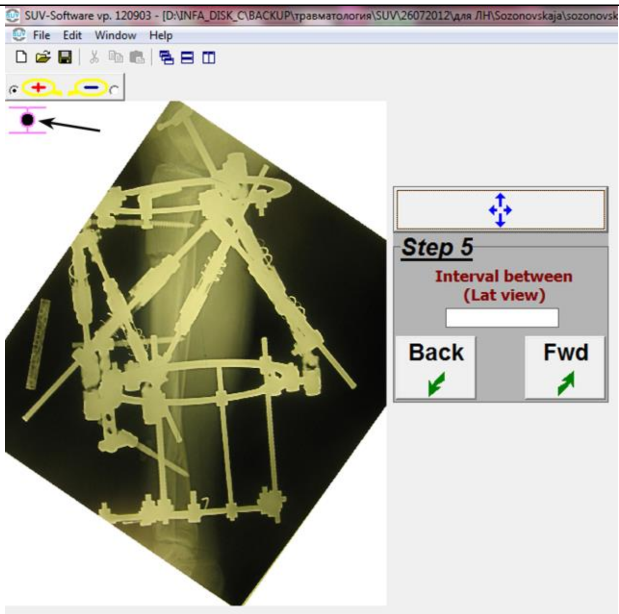


b

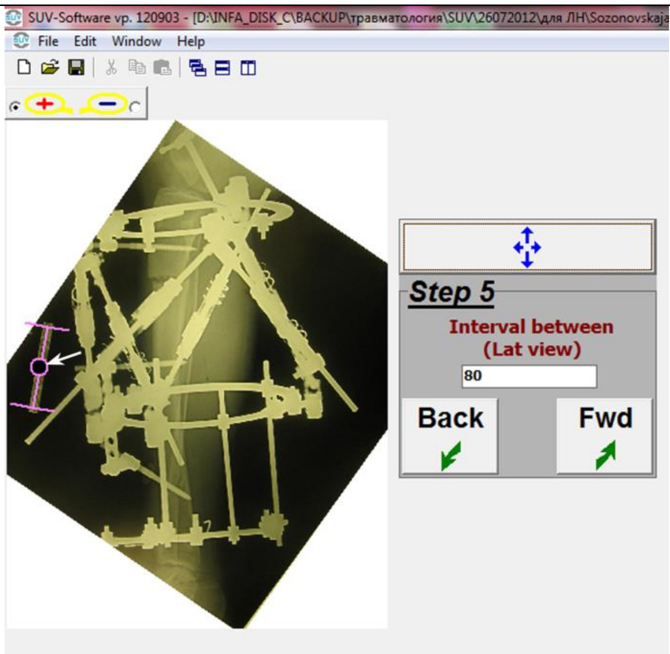
Fig. 43. Ortho-SUV software window in Step 4: «Scaling of AP view» (analog roentgenogram was the initial source). **a** – prior to scaling. "Dumbbell" is outside of field of roentgenogram. **b** – after scaling. Both ends of "dumbbell" are overlapped with ends of the roentgenogram. Field “Interval between” is filled according to width of the analog roentgenogram - 298 mm

Step 5: Scaling of the Lateral View

Lateral view scaling is implemented in the same way as described for the AP view (Figs. 44 and 45). Click on the “Forward” button to continue to the next step.

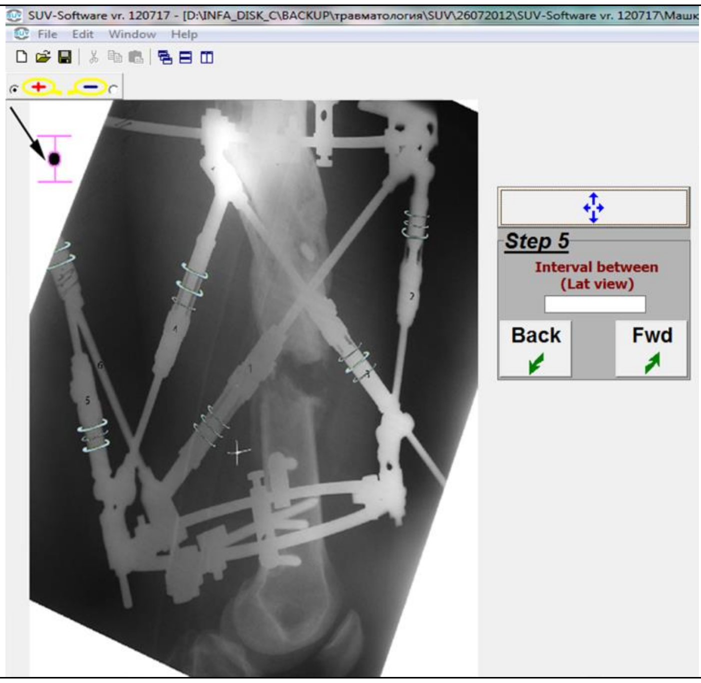


a

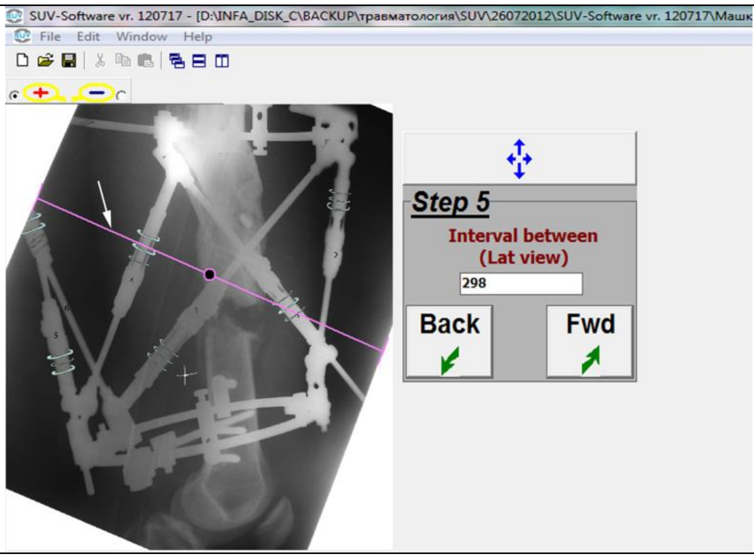


b

Fig. 44. Ortho-SUV software window in Step 5: Scaling of lateral view (digital roentgenogram was the initial source). **a** – prior to scaling. "Dumbbell" is outside of field of roentgenogram. **b** – after scaling. Both ends of "dumbbell" are overlapped with ruler. Field “Interval between” is filled in according to length of ruler - 80 mm



a



b

Fig. 45. Ortho-SUV software window in Step 5: Scaling of AP view (analog roentgenogram was the initial source). **a** – prior to scaling. "Dumbbell" is outside of field of roentgenogram. **b** – after scaling. Both ends of "dumbbell" are overlapped with ends of the roentgenogram. Field “Interval between” is filled in according to width of the analog roentgenogram - 298 mm

Step 6: Entering the Focal Distance and Beam Center; Indicating Strut and Joint Projections on the AP View

Type in the value of the *focal distance* for the AP view, i.e., the distance between the anode of the X-ray tube and the plate-holder, in the field “Focal distance (AP view)” in mm (Fig. 30).

After that on the field of the roentgenogram, mark *the X-ray beam center*. For this purpose put "tick" in a field of the panel “Beam center”. Then bring the cursor to the label on the roentgenogram indicating the centre of the beam (Fig. 31) and press the left button of the mouse. In the field of the cursor a dark blue dagger with the red centre will appear (Fig. 46).

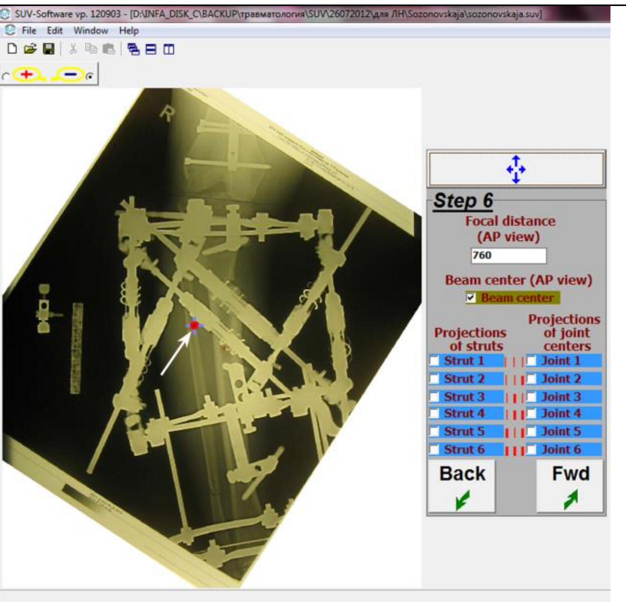


Fig. 46. Ortho-SUV software window in Step 6. The focal distance has been entered (760 mm) and the X-ray beam center marked. An arrow points to the marker of the beam center

The next stage involves marking the *strut and joint projections* on the AP view (Figs. 47 and 48).

NB!

The strut and joint numbers indicated in the program must be the same as the strut and joint numbers used in the external fixation device calculations. Arbitrary designation of the numbers is not allowed.

The simplest way to identify strut numbers on the roentgenograms is to use the X-ray-positive markers of the strut numbers (section 5.2, Fig. 32).

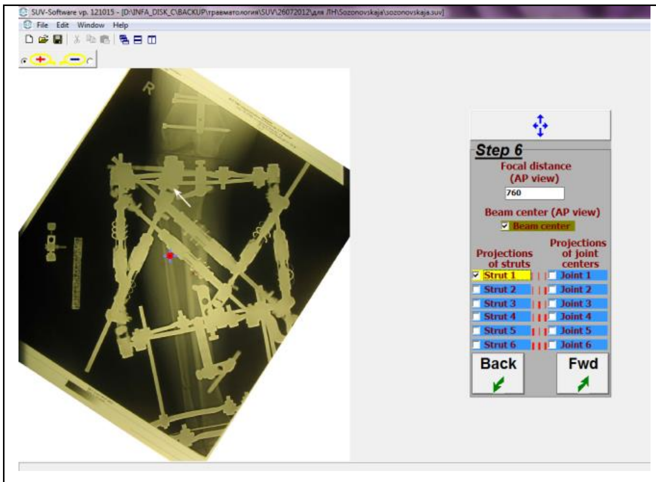
NB!

If the projection of any strut or joint is doubtful or invisible (outside the roentgenogram or is covered by other details of the frame), this strut or joint can be ignored. The software does not demand a designation of all struts and joints. As a rule, it is enough to note three struts and two not connected with them joints. But if AP and lateral view were made not perpendicularly each other, it is necessary to mark all struts and joints that can be seen.

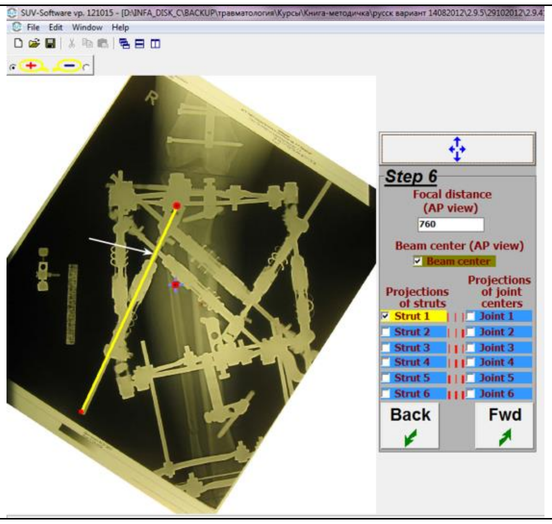
In order to mark the strut projection, click in the field of the strut appropriate number. Then bring the cursor to *the centre of joint* the same number. Then, while left-clicking the mouse, drag the line along the projection of this strut onto the X-ray image (Fig. 47). The line should be drawn strictly along the strut centre. For correction of position of the line, bring the cursor to any of its ends, press the left button of the mouse and move the line in a necessary direction. If the centre of joint is invisible, draw the line in a projection of a seen part of strut.

NB!

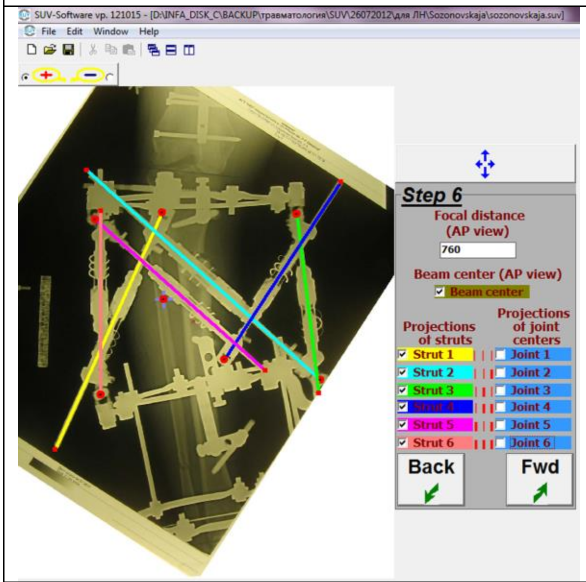
As joints of struts ## 1, 3 and 5 are fixed to the proximal ring, lines for these struts must be drawn top-down. As joints of struts ## 2, 4 and 6 are fixed to the distal ring, lines for these struts must be drawn bottom-up.



a



b



c

Fig. 47. Ortho-SUV software window in Step 6: Indicating the strut projection. **a** - in field “Strut 1” the tick is put. The cursor is brought to area joint #1 (pointed by arrow). **b** – while-pressing left button of the mouse, line in projection of centre of strut #1 is drawn. **c** - all well seen struts are marked

After that *projections of strut joints* must be drawn. For this purpose in a field “Projections of joint centers” put a tick opposite to joint number which is going to be designated. This results in the fact that around of the point designating the "joint end" of the strut line, a small circle with a small line appeared. The line of small circle has a red point on its end. Move the cursor to this point, press the left button of the mouse and move it so that a line, connecting with small circle became axial line of joint (Fig. 48).

Accuracy of lines drawn in the projection of struts and joints should be checked up in a mode of image magnification. If some of lines are not precisely in a projection of an axis of strut or joint, aim the cursor at any of three red points and while left-clicking the mouse, move the drawn lines in the necessary direction.

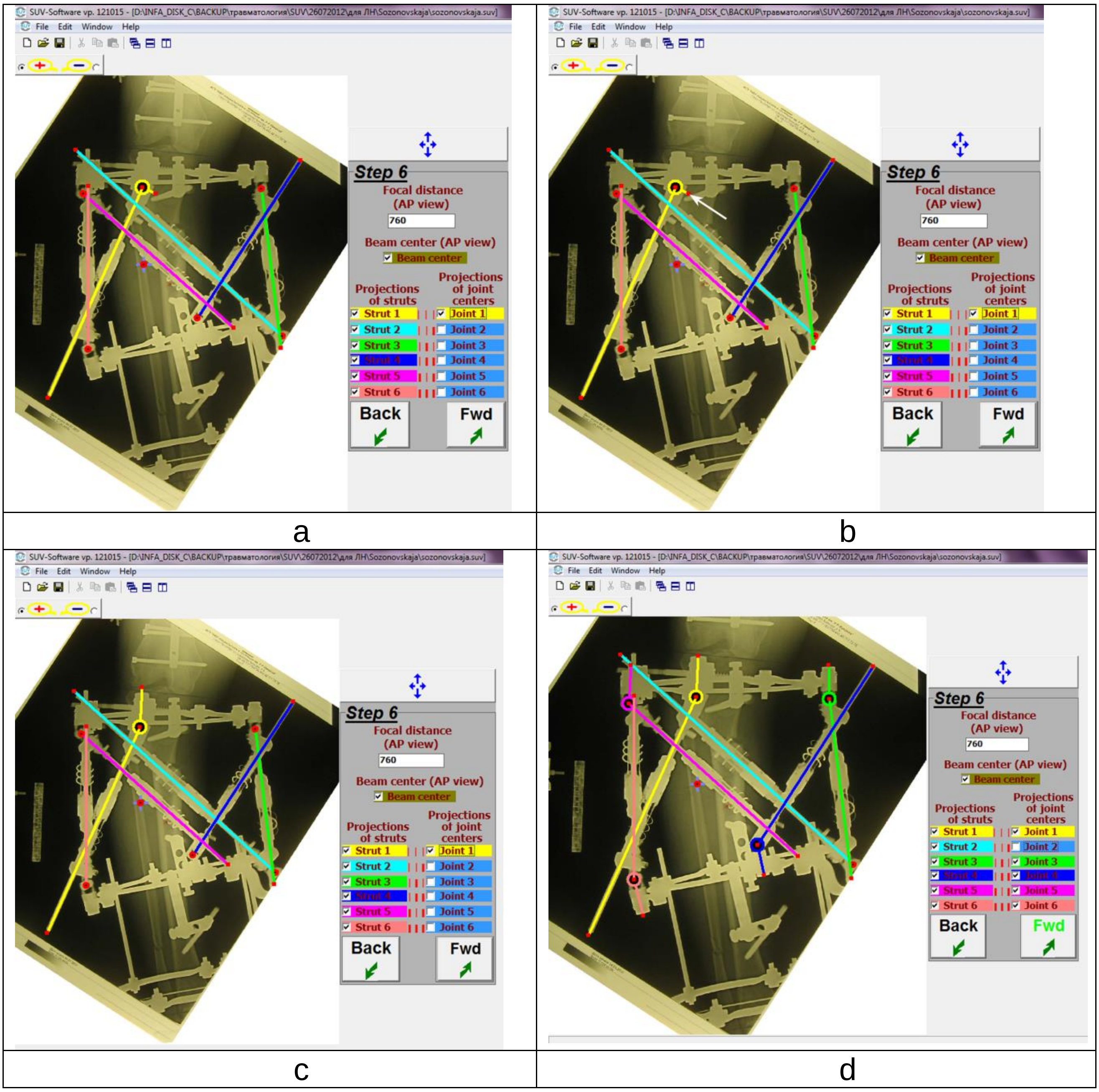


Fig. 48. Ortho-SUV software window in Step 6: Indicating the joint and strut projection. **a** – in field “Joint 1” put tick opposite to joint number which is going to be designated. This results in that around of a point designating the "joint end" of the strut line, a small circle with a small line appeared. **b -** cursor is brought to red point of cardan line (marked by arrow). **c -** while left-clicking mouse, line in projection of the centre of joint #1 is drawn. **d -** all well seen cardan joints are marked. NB! Button "Fwd" changed color with black on green that allows making the following step

As soon as the program has enough information to continue, the “Fwd” sign turns green, at which point continuation to the next step is possible.

Step 7: Indicating the Focal Distance and Beam Center, and the Strut and Joint Projections on the Lateral View

Step 7 (Figs. 49 - 51) is carried out essentially as described for Step 6. Here, it must again be emphasized that the numbers assigned to the strut and the joints in the program must correspond to those used in the corresponding frame calculations. The arbitrary designation of numbers is not allowed.

As a rule, for the program to work successfully, it is sufficient to indicate three struts and one joint, with the joint numbered differently from the indicated struts. The struts and joints indicated on AP and lateral roentgenograms might not coincide. In other words, the AP view might feature one set of indicated joints and struts, and the lateral view another.

As soon as the program has enough information to continue, the "Fwd" button turns green and it is possible to continue to the following step.

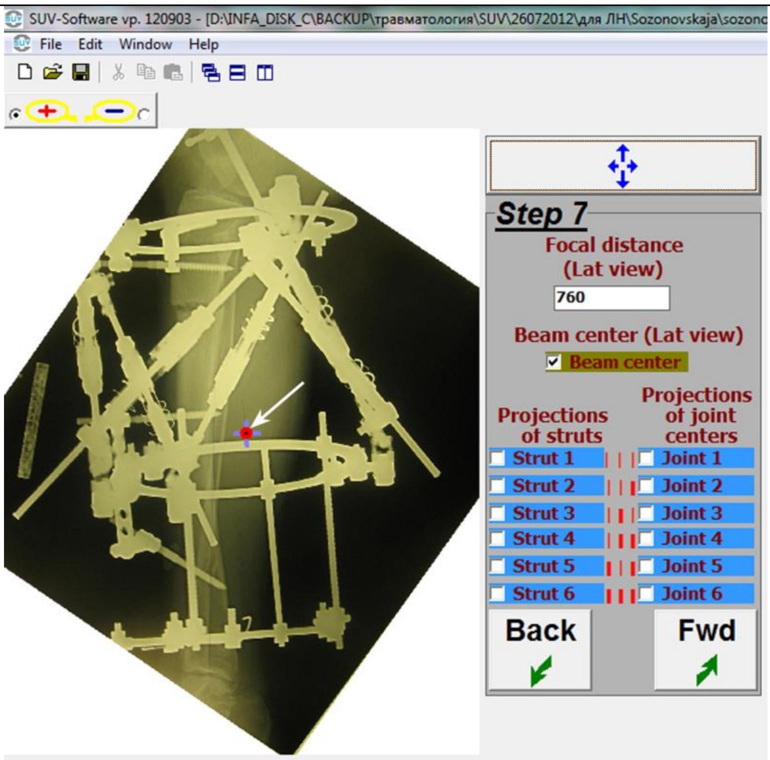


Fig. 49. Ortho-SUV software window in Step 7 for lateral view. The focal distance has been entered (760 mm) and the X-ray beam center marked. An arrow points to the marker of the beam center

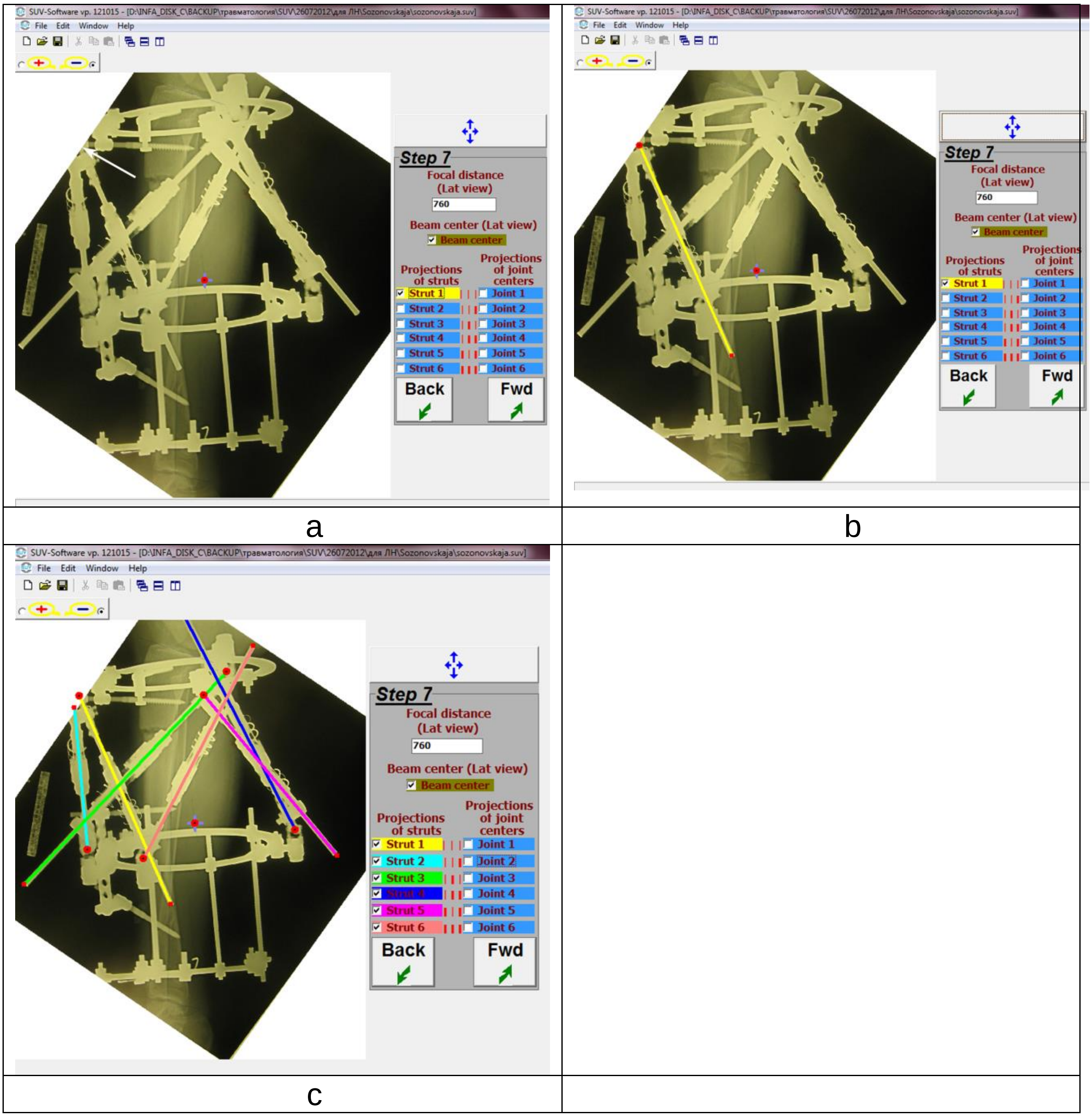


Fig. 50. Ortho-SUV software window in Step 7: Indicating the strut projection on Lat view. **a** - in a field “Strut 1” the tick is put. The cursor is brought to area joint #1 (pointed by arrow). **b** – while-pressing left button of the mouse, line in projection of the centre of strut #1 is drawn. **c** - all well seen struts are marked

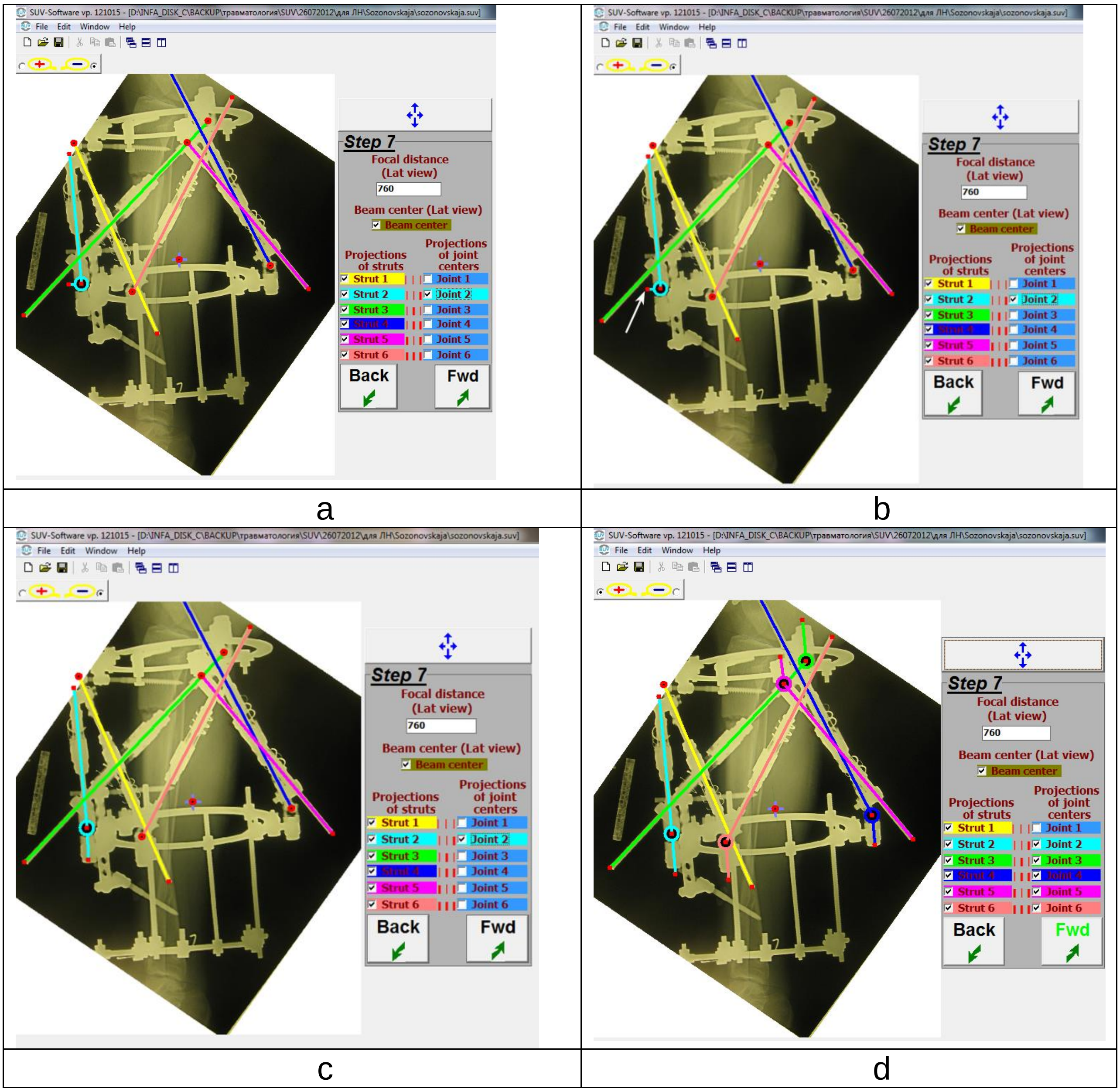
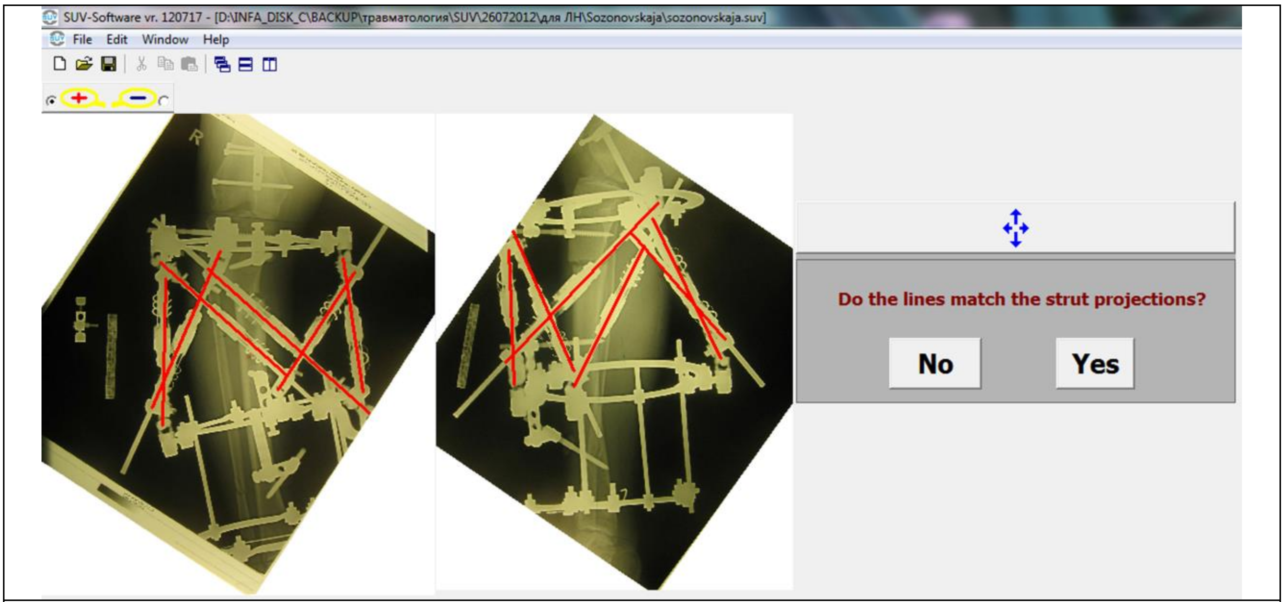


Fig. 51. Ortho-SUV software window in Step 7: Indicating the joint and strut projection on lateral view. **a** – in field “Joint 1” put tick opposite to joint number which is going to be designated. This results in that around of a point designating the "joint end" of the strut line, a small circle with a small line appeared. **b -** cursor is brought to red point of cardan line (marked by arrow). **c -** while left-clicking mouse, line in projection of the centre of joint #1 is drawn. **d -** all well seen cardan joints are marked. NB! Button "Fwd" changed color black for green that allows making the following step

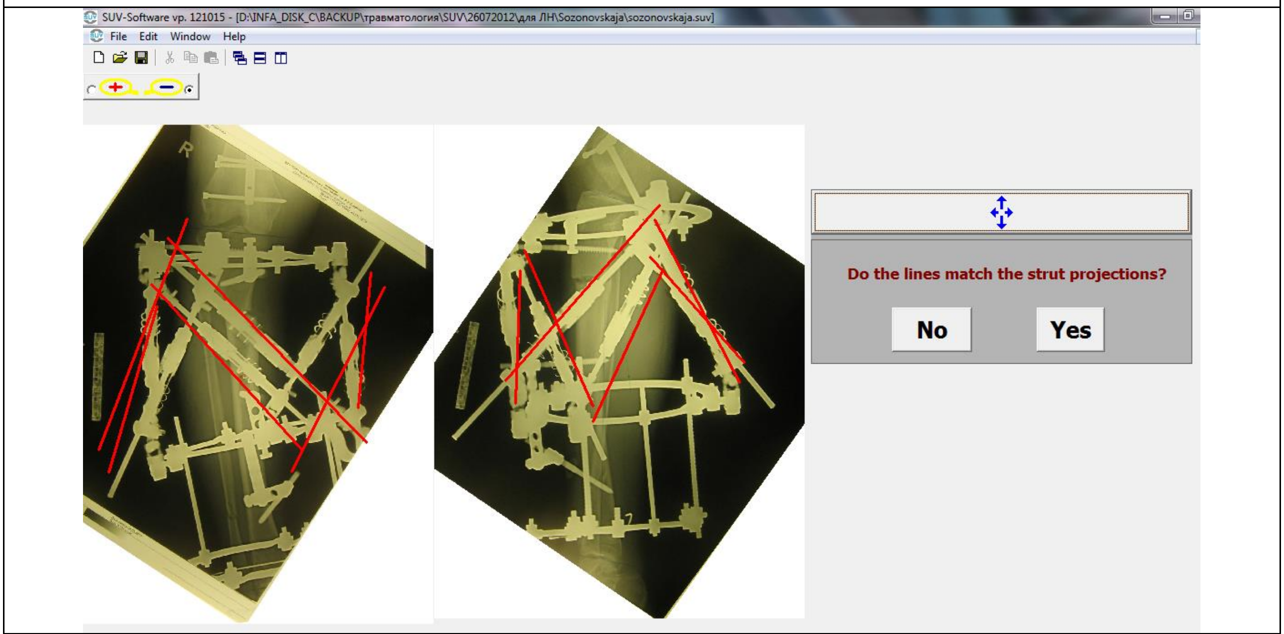
After the forward button has been clicked on, the program analyses all the data entered at all previous steps. This takes, depending on computer power, 10 sec to 2 min. When the calculation has been completed, red lines will appear on both images: six on the AP view and six on the lateral view. These lines have to exactly match the projections of all strut axes. Permissible deviation is limited by a strut width as it appears on the image. *The congruency between red lines and struts serves as a criterion of* *correct data input* (Fig. 52). If this congruency is present for all the struts, click “Yes” and continue to the next step.

NNB!!

If even a single red line does not match a strut seen on the roentgenogram, click “No” to return to Step 7. Then it is necessary to return to all previous steps and consistently check all data input. *Only when congruency between all red lines and all strut projections is achieved one may continue to the next step!*



a



b

Fig. 52. Ortho-SUV software window in Step 7 after the program has analysed all data input. **a** – all red lines match strut projections. Button "Yes" must be pressed. **b** – some lines do not coincide with strut projection. It is necessary to press button "No" and to check up ALL data which were input at each previous steps

Step 8: Drawing the Bone Contours

The contour of *the mobile* bone fragment is outlined with a yellow line on the AP and lateral views. For accurate matching yellow lines to a contour of a bone fragment it must be made at the maximal magnification.

Note, that length of bone contour has no principle importance for the software. Therefore it is not necessary to draw contours of all distal fragment: from the proximal end up to joint line. Length of bone contour 1-2 cm is permitable. But in this case in the Step 11 it will be very difficult to understand, what final position of distal fragments is recommended by the software. Therefore recommended length of bone contour must not be less than 3-4 cm (Fig. 53).

Also it is necessary to take into consideration that *axes (mid lines) of bone contours* (Step 9) must be drawn 2-3 cm out of bone contours border. Therefore the distal border of bone contour must be over 3 cm above the distal border of the roentgenogram field.

To make a bone contour place the cursor on a cortex of mobile fragment. Press the left button of the mouse and than release it. Yellow point will appears on the screen. Move the cursor on other point of the cortex and press the left button of the mouse again. A line connecting the new point with the previous one will appear. By successive drawing of necessary number of lines, make outline of bone fragment (Fig. 53).

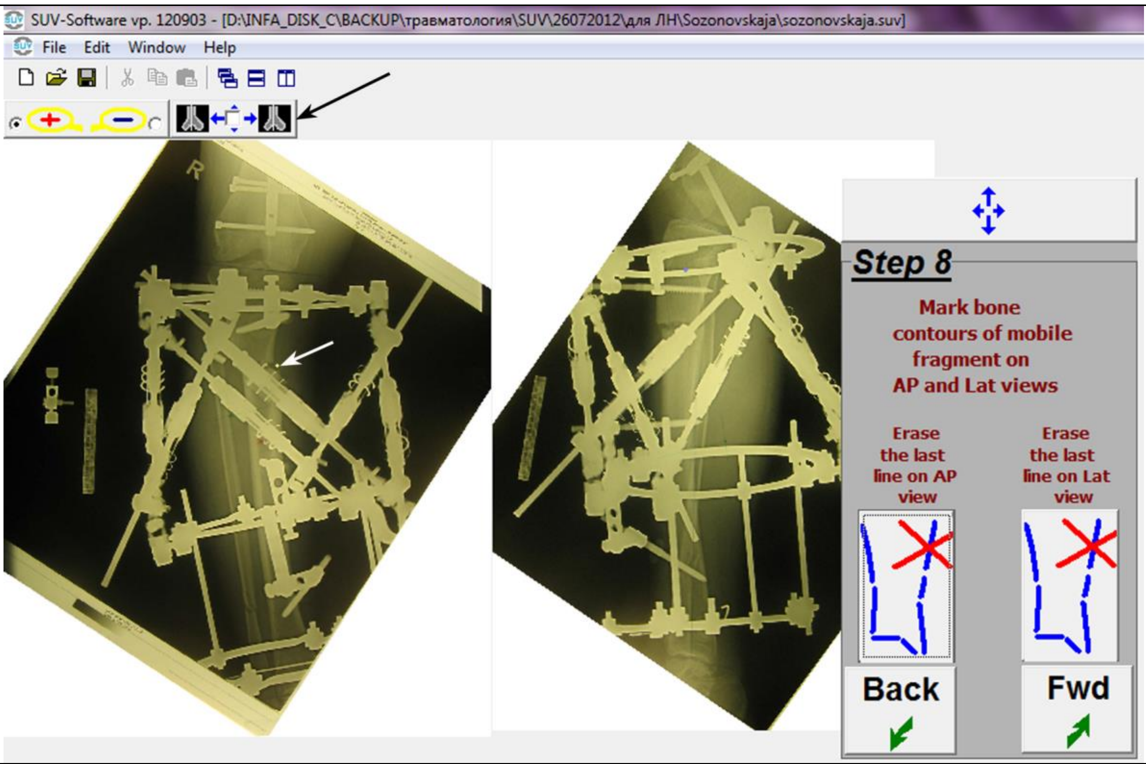
If the last fragment of the line is drawn incorrectly, use the button "Erase the last line."

Note that in the Step 8 in the panel of tools there is *a button of moving of fields of roentgenograms* (Fig. 53). This button is used when it is necessary to move a field of x-ray picture on the screen, and to increase or reduce (in a combination with the button zoom in / zoom out) the roentgenogram. Use the button as follows: pressing left mouse in field of this button results in appearance of a tick. It means, that the function of moving is switched on and drawing the bone contour is blocked. Moving x-ray picture and its reduction / magnification should be done in the same way as it was described in Step 4. After required action has been done (moving of a x-ray picture or its reduction / magnification), you *must switch this button off*. After that drawing bone contour can be continued.

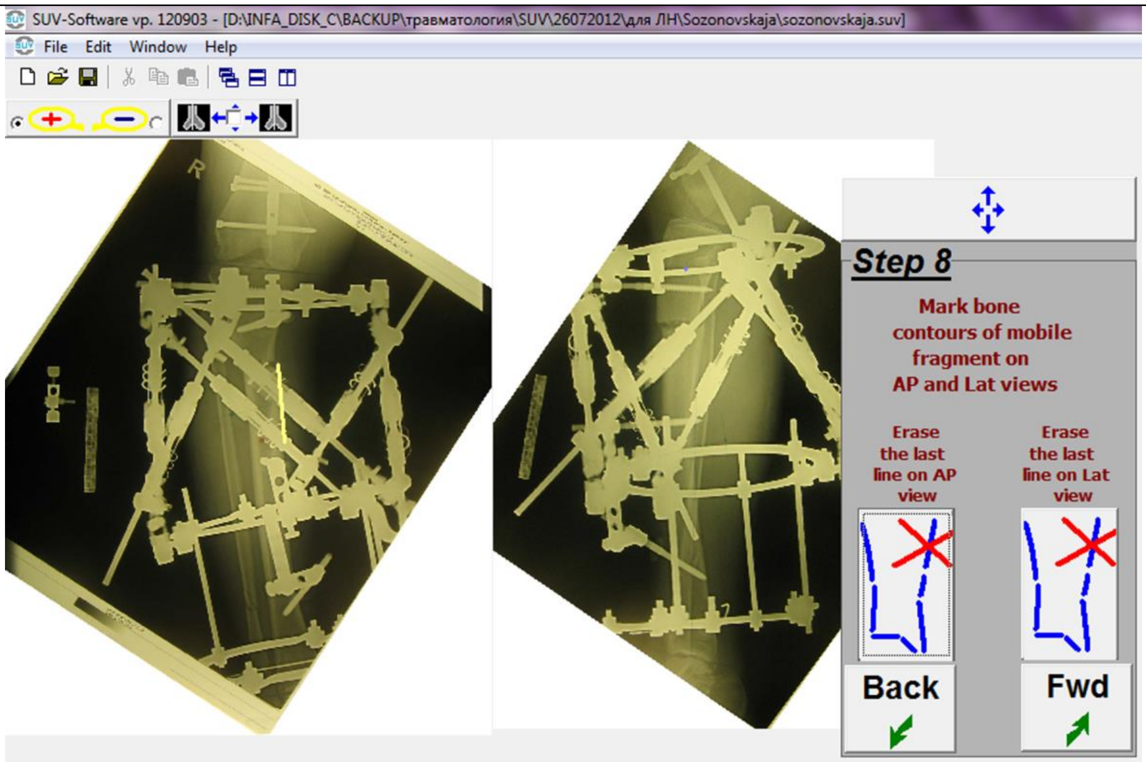
NB!

Lengths of bone contours on AP and Lat view must be of equal length.

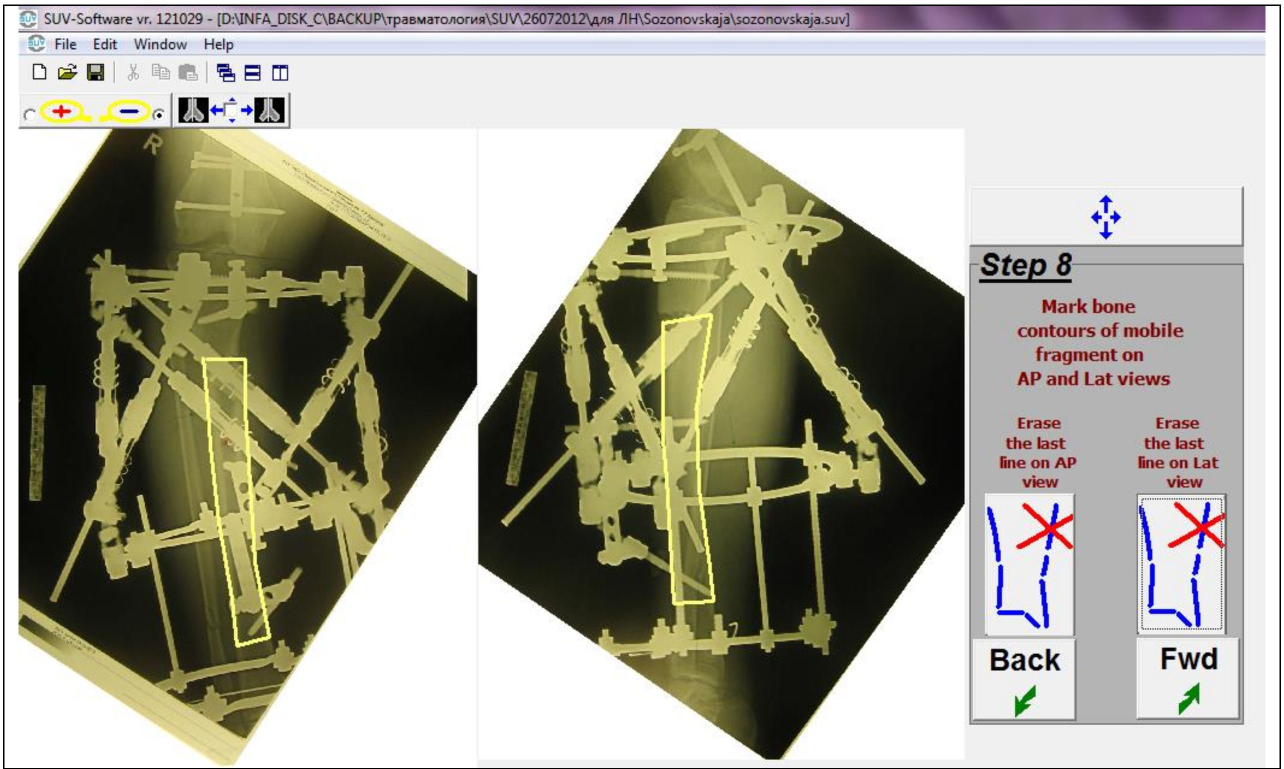
Once the bone contours have been drawn on the AP and lateral views, click the "Fwd" button.


SUV-Software vp. 120903 - [D:\INFA_DISK_C\BACKUP\травматология\SUV\26072012\для ЛН\Sozonovskaja\sozonovskaja.suv]
File Edit Window Help
Step 8
Mark bone contours of mobile fragment on AP and Lat views
Erase the last line on AP view
Erase the last line on Lat view
Back
Fwd

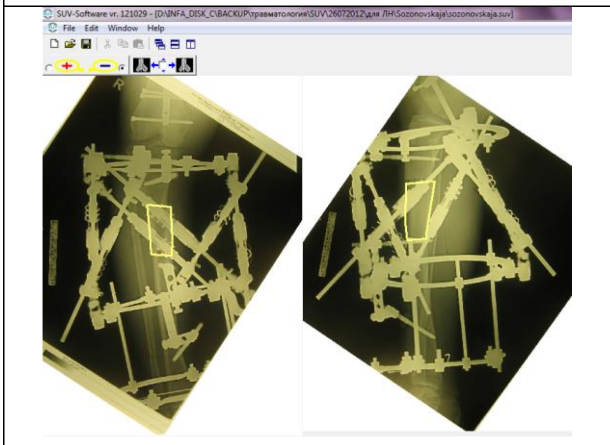
a


SUV-Software vp. 120903 - [D:\INFA_DISK_C\BACKUP\травматология\SUV\26072012\для ЛН\Sozonovskaja\sozonovskaja.suv]
File Edit Window Help
Step 8
Mark bone contours of mobile fragment on AP and Lat views
Erase the last line on AP view
Erase the last line on Lat view
Back
Fwd

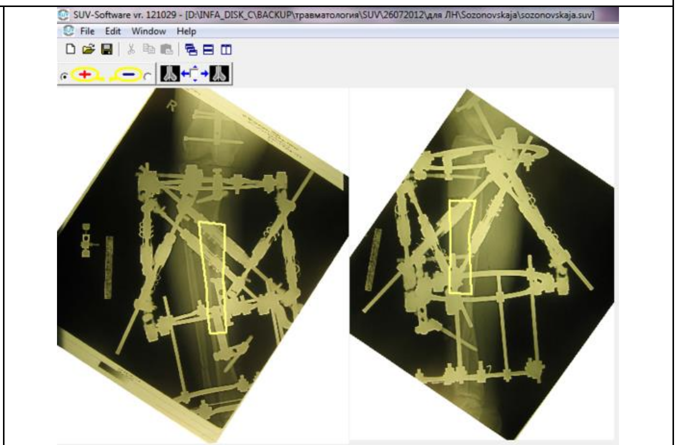
b



c



d



e

Fig. 53. Ortho-SUV software window in Step 8. **a** – arrow points *the button of moving of fields of roentgenograms.* On AP view arrow indicates the yellow point made by cursor. **b** – yellow line in projection of cortex of distal fragment (AP view) is drawn. **c –** yellow bone contours on AP and Lat view are done. Note that bone contours are of equal length. **d, e -** possible variants of bone contours of mobile fragment

Step 9: Marking the Anatomic Axes of the Bone Contours on the AP and Lateral Views

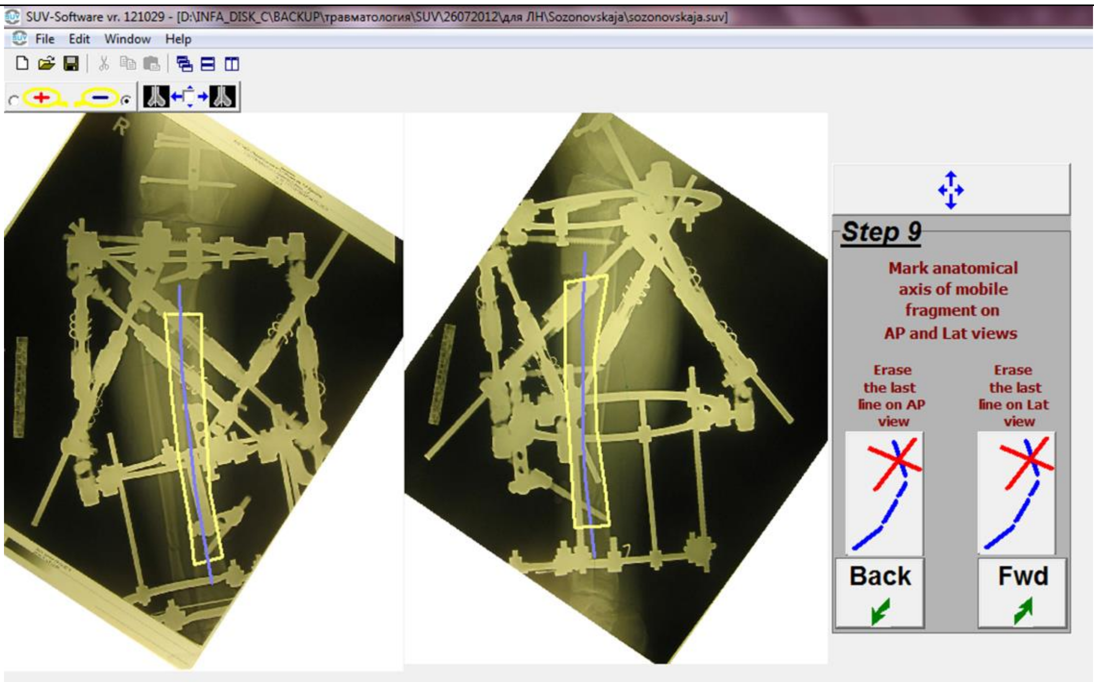
To mark the anatomic axis, the cursor is placed in the center of the bone contours of the mobile bone fragment, 2-3 centimeters above its proximal end. Pressing the left button of the mouse, make points, which the program connects in a line. If there are bends of bone fragment, line must replicate them, because it must be "mid-diaphyseal line of the bone contour". Axis of bone contour must be done both on AP and Lat view (Fig. 54).

If the last fragment of the line is drawn incorrectly, use the button "Erase the last line."

After drawing blue lines on AP and Lat view, press button "Fwd". If the note "Precise the anatomical axes sizes" appears, it is necessary to remove axes of bone contours and draw the new one which exceeds more proximal and distal ends of bone contour.

NB!

The anatomic axes of the bone contour must exceed its proximal and distal ends by 2-3 centimeters. If the X-ray image is short and it is impossible to draw the blue line above the distal end of the bone contour, the operator must return to Step 8, remove the bone contour, and draw a new, shorter one.



a

b

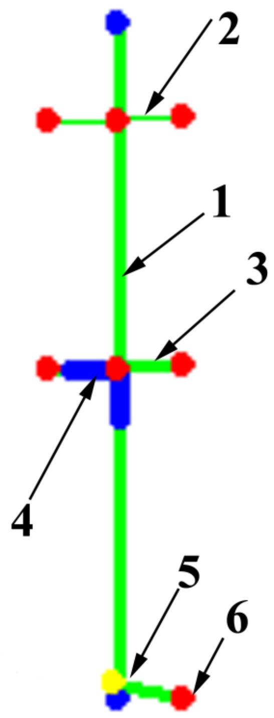
Fig. 54. Ortho-SUV program window after completion of Step 9. **a** - on AP and Lat view anatomical axes of yellow bone contours are drawn. **b** – if there are bends of bone fragment, axes should replicate them, because it must be “mid-diaphyseal line of bone contour”. The anatomic axes of the bone contour must exceed its proximal and distal ends by 2-3 centimeters

Step 10: Marking the Bone Fragment Axes

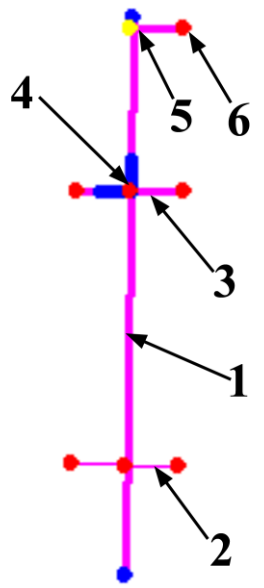
Special tools are used to mark the axes of both the basic and the mobile bone fragments, *the bone fragment markers* (“trees”). The basic fragment marker is colored green, and the mobile fragment marker is violet. So we have a *green tree* and a *violet tree*.

Fragment markers consist of (Fig. 55):

- the axial line (1);
- two centrators (2 and 3);
- the indicator of an angle of axial line positioning (“blue angle”) (4). Blue angle is placed on one of the centrators;
- the pointer of bone fragment border (“yellow point”) (5). The yellow point is connected to the red point (6).



a



b

Fig. 55. Bone fragment markers (**a** – proximal and **b** – distal) in Ortho-SUV software: “green tree” and “violet tree”. 1 – axial line; 2 – first centrator; 3 – second centrator; 4 – indicator of an angle of axial line positioning (“blue angle”); 5 – pointer of bone fragment border (“yellow point”); 6 – red point providing moving of yellow point (5) along axial line (1)

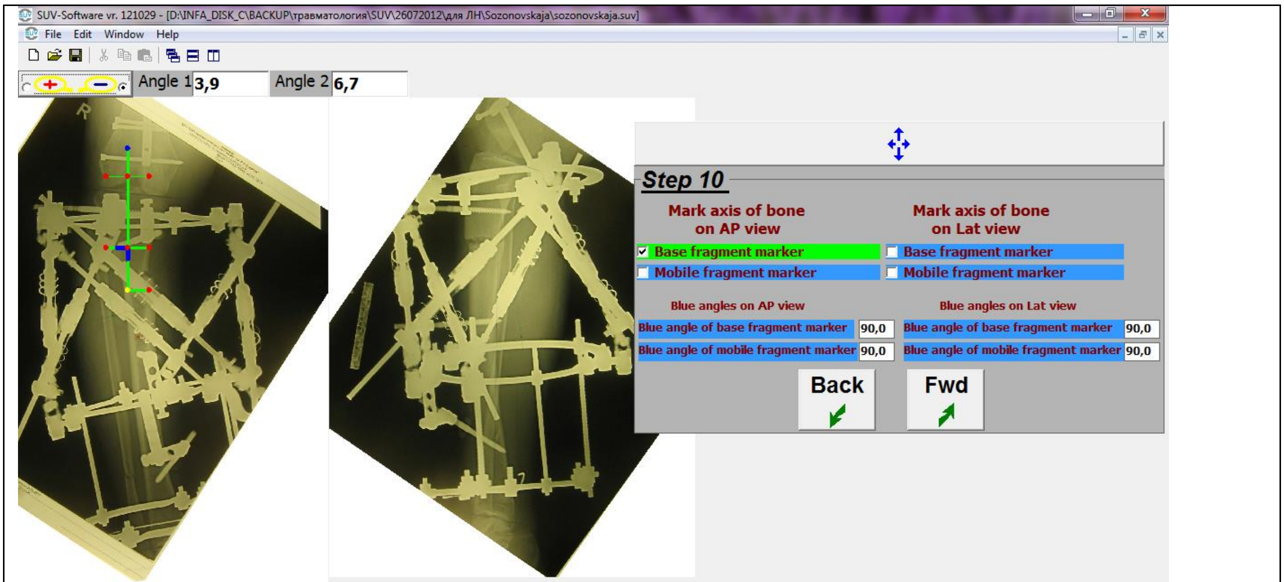
During work with the software axial lines of trees are placed according to anatomic (mid-diaphysial lines) or mechanical axes of bone fragments. It depends on what axes (anatomic or mechanical) are used for planning of deformity correction.

*Setting of fragment markers according to **anatomic** axes*

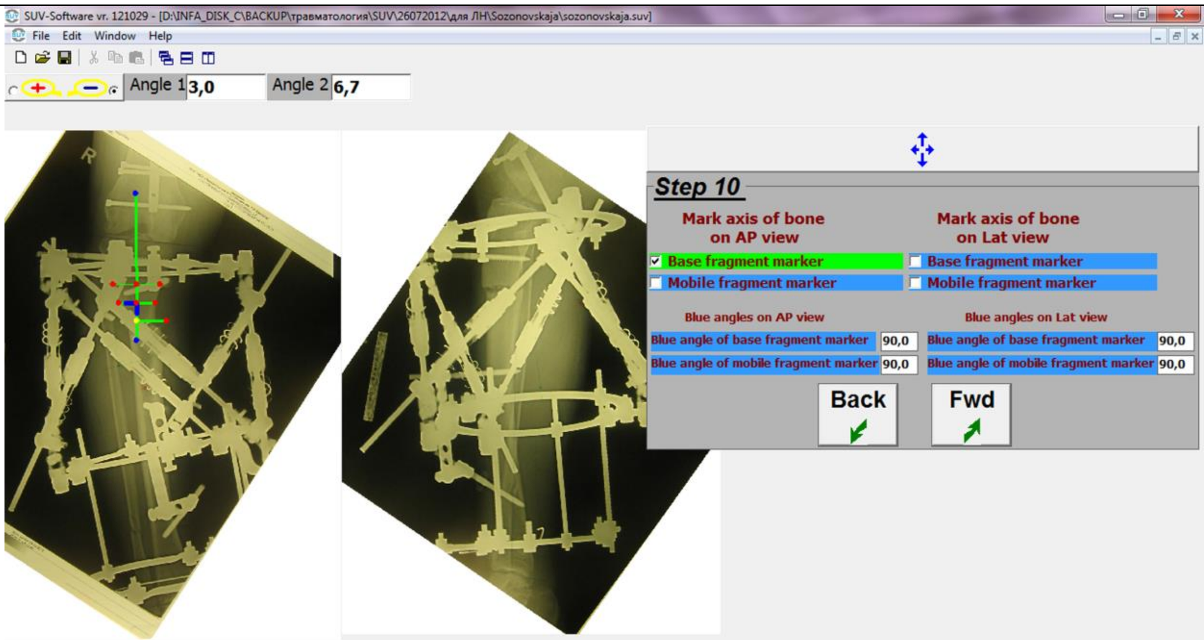
At first fragment marker of proximal fragment in frontal plane should be set. For this purpose tick in the field "Base fragment marker (AP view)”. Then move the cursor of the mouse on proximal end of the basic fragment. While left-clicking the mouse, draw an axial line of the basic bone fragment on the frontal roentgenogram *top-down*. After that the marker of the basic bone fragment (green tree) will appear (Fig. 56).

If the position of base fragment marker is correct, yellow point will be in area of distal border of proximal fragment. If an operator has mistakenly dragged the line not from bottom to top, but from top to bottom, the yellow point will assume the wrong location, that is at the very top of the fragment marker. To correct this mistake, remove the tick in the field “Base fragment marker (AP view)”, place the cursor over the image of the AP view, and left-click the mouse once. The fragment marker will disappear. Then, go through the algorithm again, this time dragging the line in the proper direction.

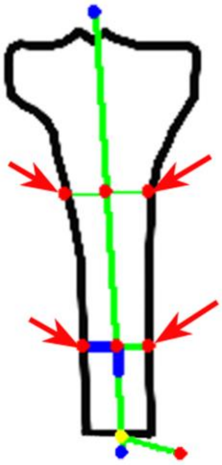
To strictly align the axis line of the fragment marker with the anatomic axis of the base bone fragment, place the cursor over the left end of the first centrator and, while left-clicking the mouse, place this point on the left cortex. Similarly, place the second outermost point of the centering line of the base bone fragment marker on the cortex positioned to the right. At a some distance from proximal centrator (depends on known rules of mid-diaphysial lines of long bones definition) similarly, place the second centrator. As a result on AP view the axial line of green tree will take place of anatomic axis of the proximal bone fragment. After that overlap the cursor with the red point, connected with the yellow point, and press the left button of the mouse. Moving upwards or downwards the red point, achieve, that the pointer of bone fragment border (“yellow point”) coincided with the distal border of proximal bone fragment (Fig. 56).



a



b

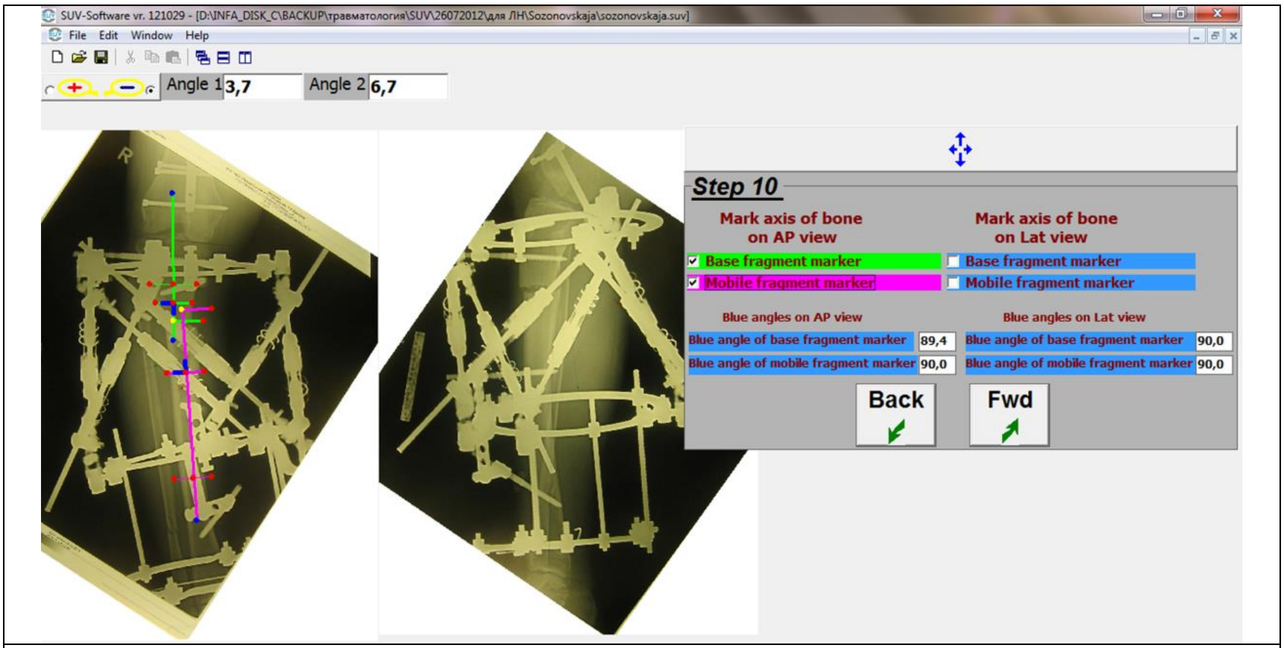


c

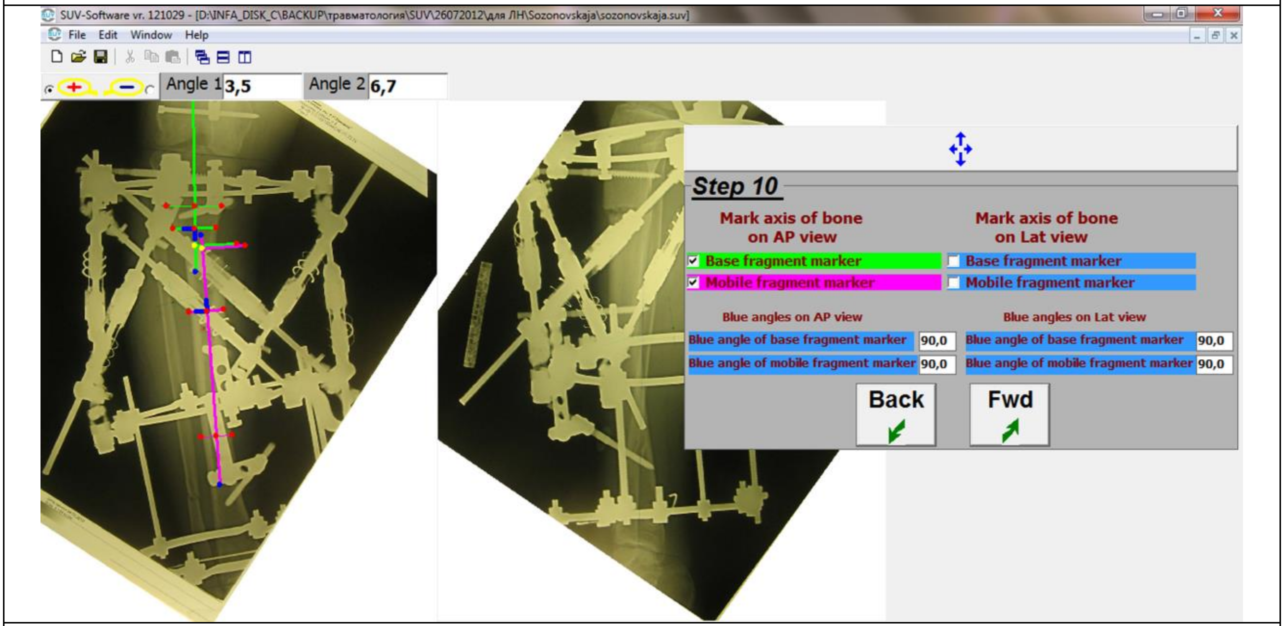
Fig. 56. Ortho-SUV software window in Step 10, at positioning of proximal bone fragment marker on AP view. **a -** field “Base fragment marker” is ticked. After that in top-down direction green tree is drawn. **b -** using centrators axial line has positioned according to mid-diaphysial line (anatomic axis of fragment). Yellow point is placed on distal border of proximal fragment. **c -** diagram. Arrows specify points of centrators, placed in projection of lateral and medial cortexes

The next stage is set of *distal fragment* bone marker in the frontal plane. For this purpose tick in the field "Mobile fragment marker (AP view)". Then move the cursor on the proximal end of the mobile fragment. While left-clicking the mouse, draw an axial line of the basic bone fragment on the frontal roentgenogram *top-down*. After that the marker of the mobile bone fragment (violet tree) will appear (Fig. 57). The yellow point should settle down in the field of the top border of the distal fragment.

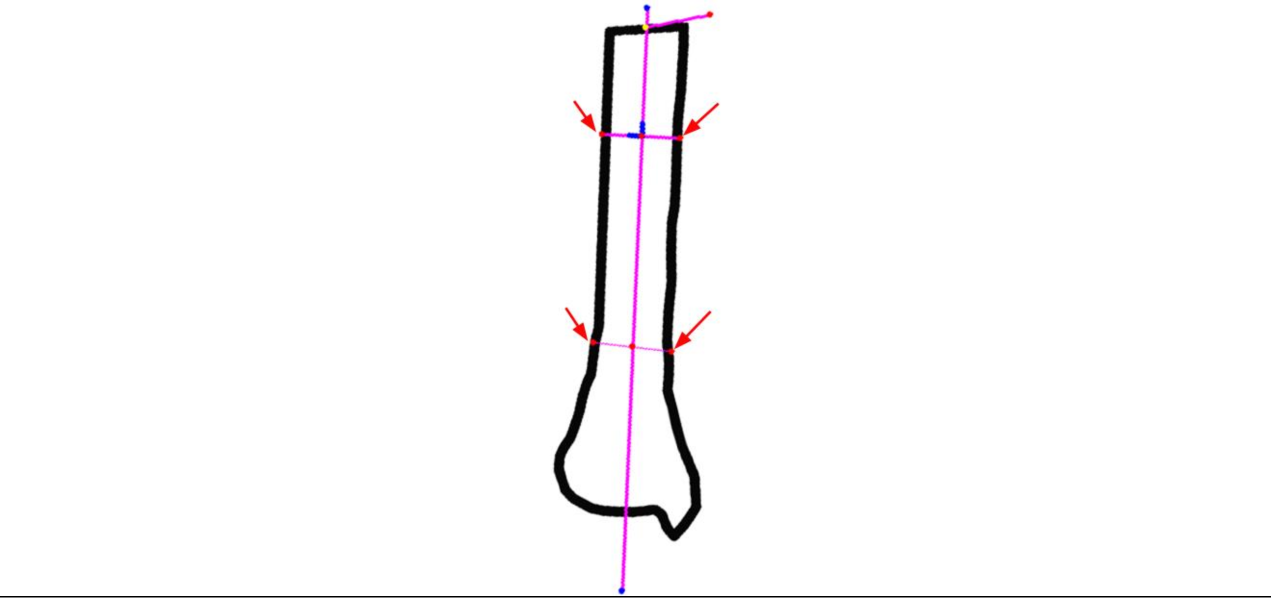
To strictly align the axis line of the fragment marker with the anatomic axis of the base bone fragment, place the cursor over the left end of the first centrator and, while left-clicking the mouse, place this point on the cortical layer positioned to the left. Similarly, place the second outermost point of the centering line of the base bone fragment marker on the cortex positioned to the right. At a some distance from proximal centrator (depends on known rules of mid-diaphysial lines of long bones definition) similarly, place the second centrator. As a result, the anatomic axis of the distal bone fragment will be positioned on AP view. After that overlap the cursor with the red point, connected with the yellow point, and press the left button of the mouse. Moving upwards or downwards the red point, achieve, that the pointer of bone fragment border ("yellow point") coincided with the proximal border of the distal bone fragment (Fig. 57).



a



b

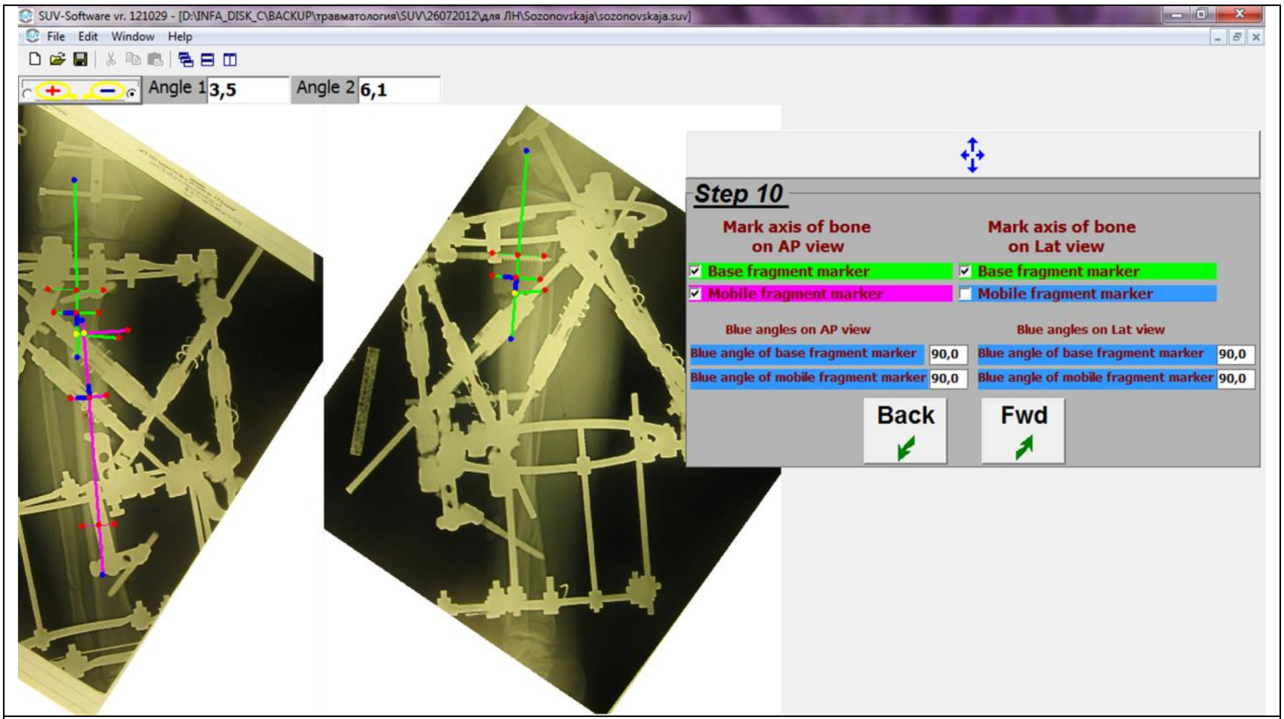


c

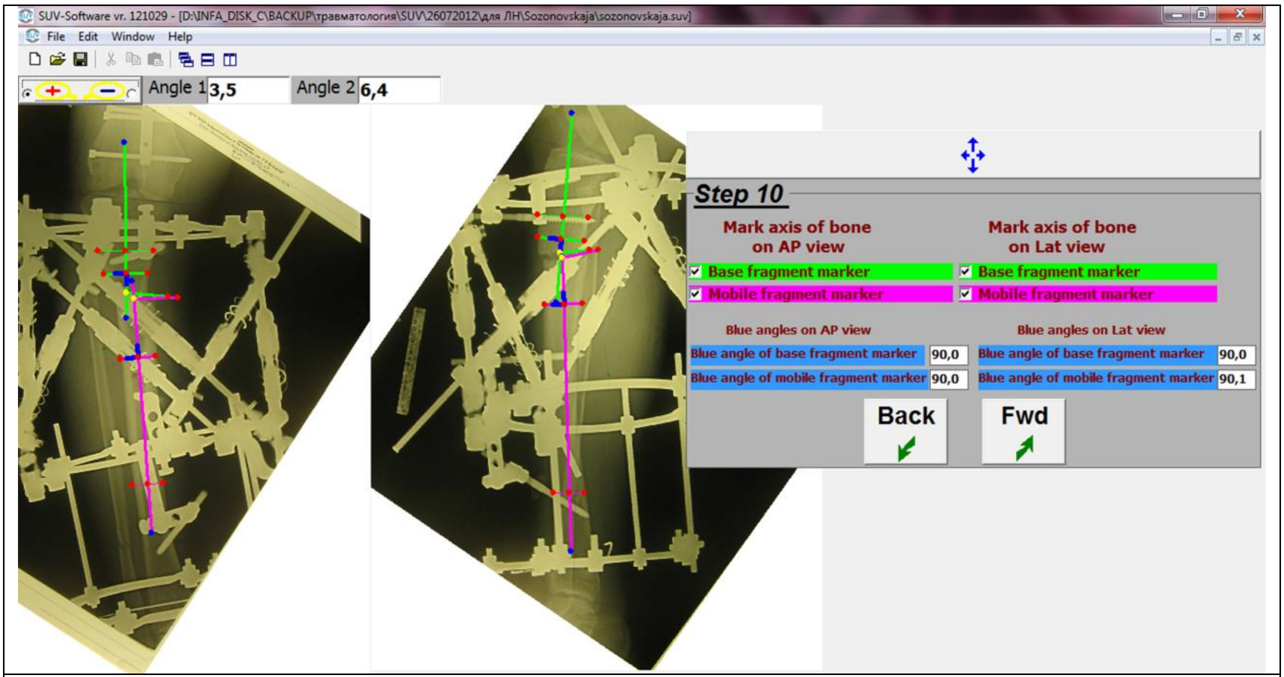
Fig. 57. Ortho-SUV software window in Step 10, at positioning of distal bone fragment marker on AP view. **a -** field “Mobile fragment marker” is ticked. After that in top-down direction violet tree is drawn. **b -** with use of centrators axial line has positioned according mid-diaphysial line (anatomic axis of fragment). Yellow point is placed on proximal border of mobile fragment. **c -** diagram. Arrows specify points of centrators, placed in projection of lateral and medial cortexes

After that, similarly, place markers of proximal and distal fragments for the Lateral view (Fig. 58).

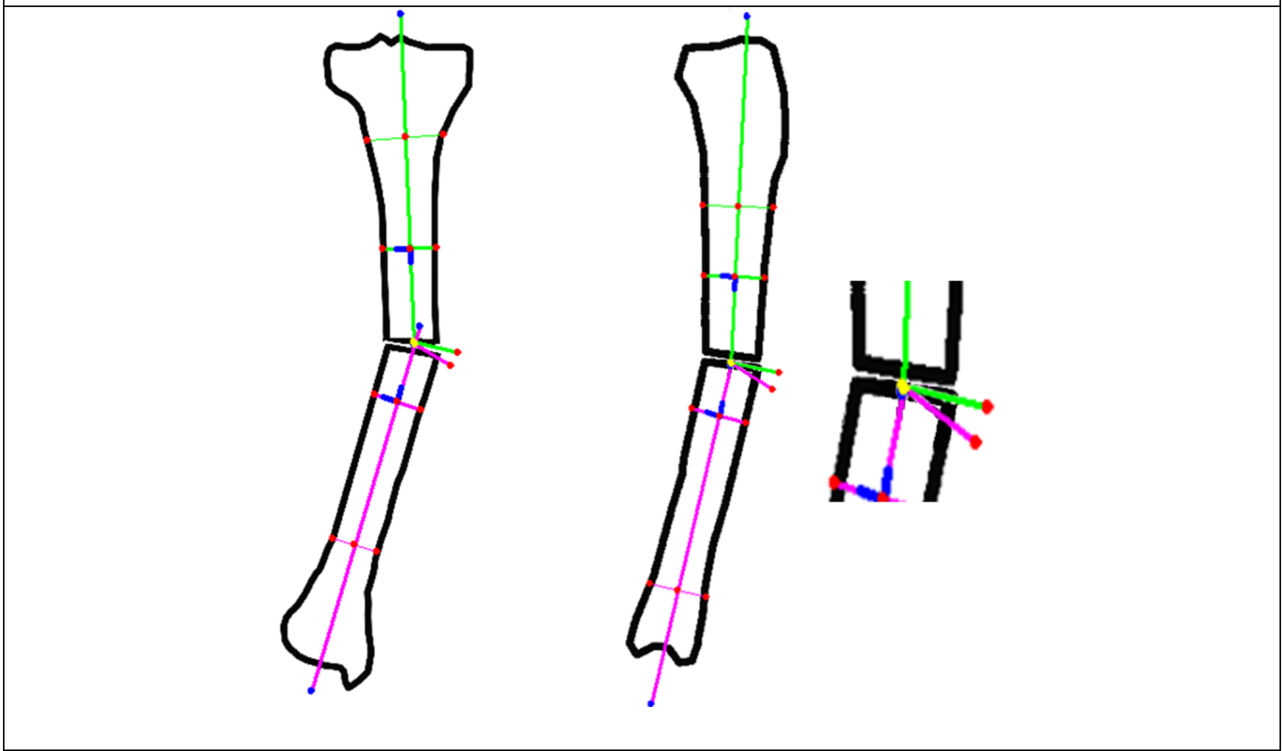
The alternative method of finding anatomic axes of bone fragments is showed in Fig. 63.



a



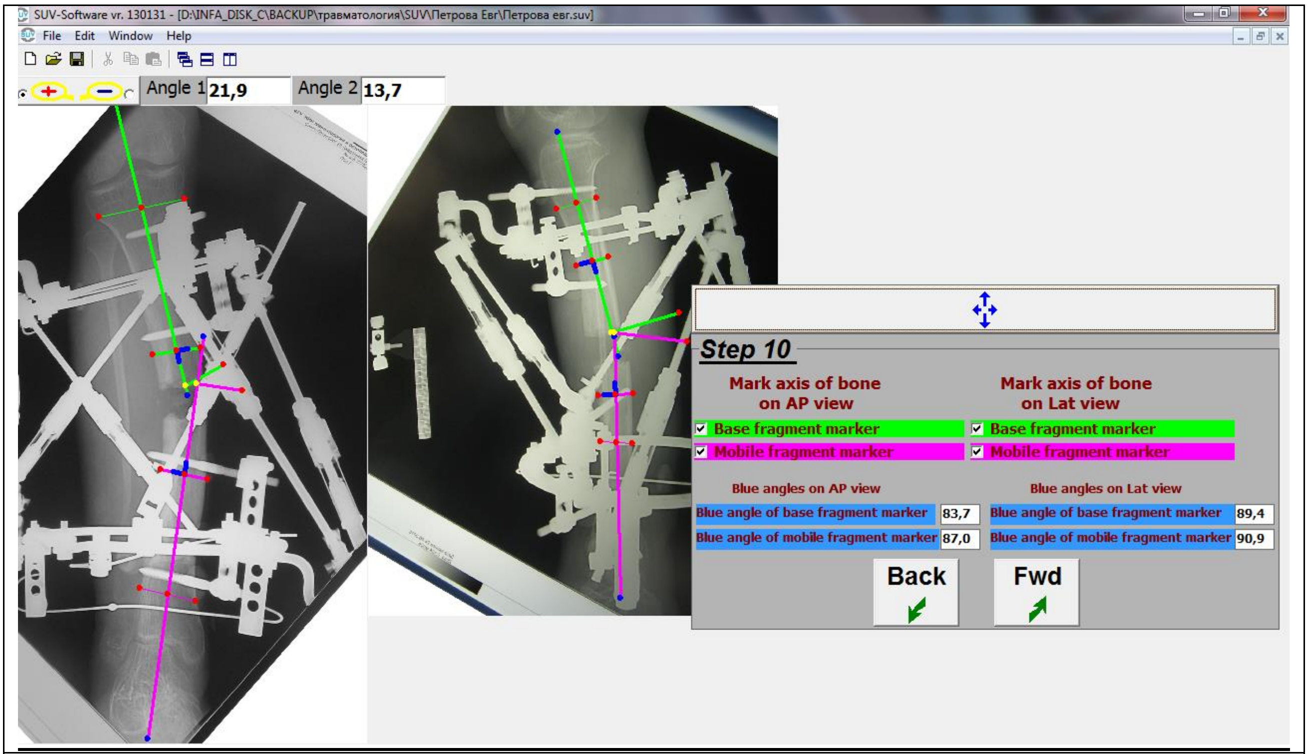
b



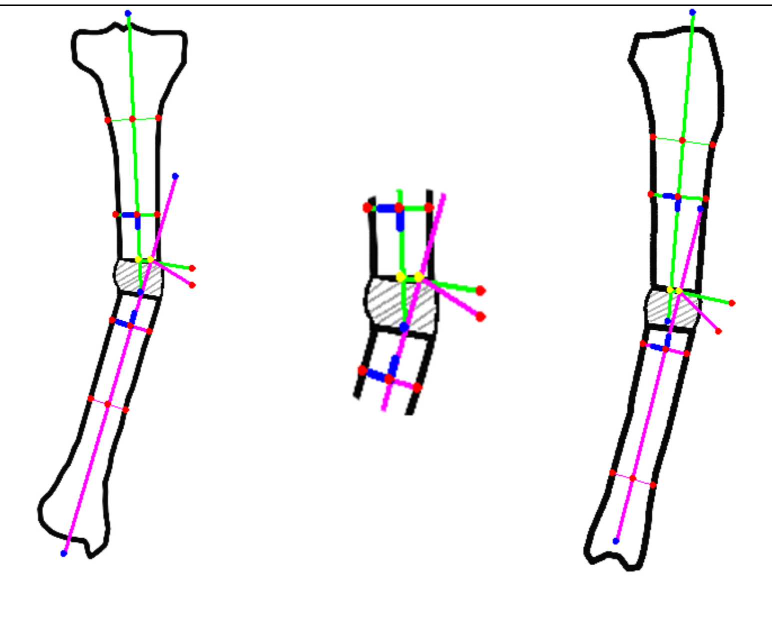
c

Fig. 58. Ortho-SUV software window in Step 10, at positioning of distal bone fragment marker on Lat view. **a -** field “Base fragment marker” is ticked. After that in top-down direction green tree is drawn. With use of centrators axial line has positioned according to mid-diaphysial line (anatomic axis of fragment). Yellow point is placed on distal border of basic fragment. **b -** field “Mobile fragment marker” is ticked. After that in top-down direction violet tree is drawn. With use of centrators axial line has positioned according mid-diaphysial line (anatomic axis of fragment). Yellow point is placed on proximal border of mobile fragment. **c -** diagram. As there is only angular deformity (no translation), yellow points of proximal and distal fragments coincide

The above mentioned method of setting the yellow points of the fragment markers should be used only in cases when there is no gap between bone fragments. In the presence of distraction regenerate yellow point of the proximal bone fragment must be set at the distal border of the proximal fragment - as it is described above. Yellow dot pointer distal fragment should be set at the same level with the yellow point of proximal bone fragment marker (Fig. 2.9.59).



a



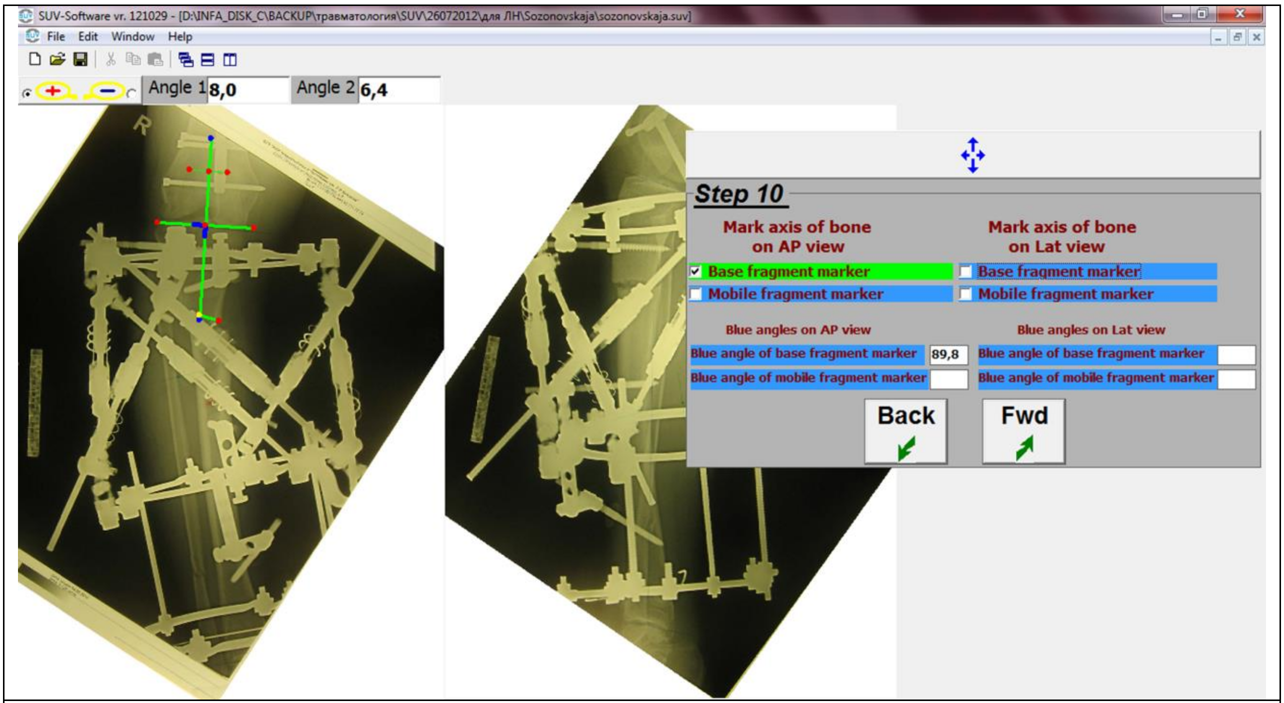
b

Fig. 59. Ortho-SUV software window in Step 10: the features of yellow points setting in presence of gap between bone fragments. **a** - yellow point of proximal

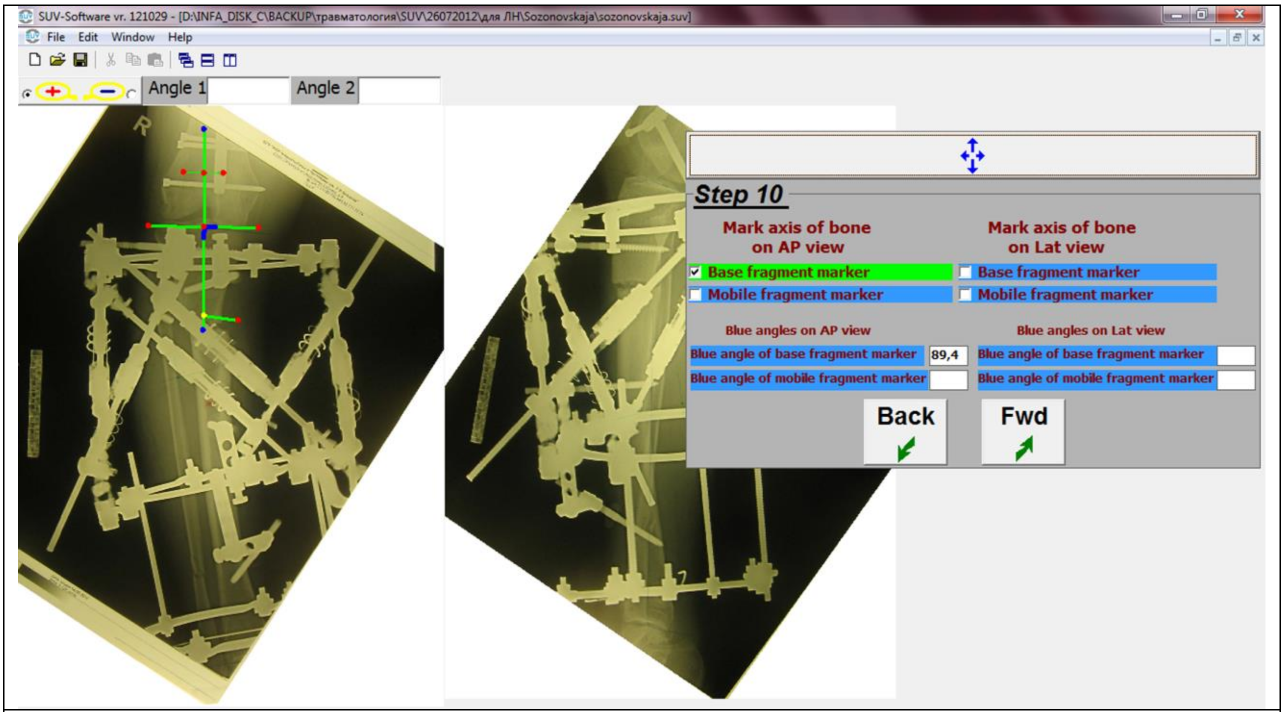
fragment marker is placed on distal border of basic fragment. Yellow point of distal fragment marker is placed at the same level with yellow point of the proximal fragment marker. **b** – scheme

Setting of fragment markers according to ***mechanical*** *axes*

The blue angle is used for finding of mechanical axis of bone fragment. It is located on one of centrators (Fig. 55). In this case centrator without the blue angle must be ignored. It should be, using its central red point, moved out of borders of bone fragment. On default the blue angle settles down to the left of an axial line. If necessary it can be placed to the right of an axial line. For this purpose overlap the cursor with left point of centrator and press the left button of the mouse. While left-clicking the mouse, move this point left-to-right. As result blue angle meets the right position (Fig. 60).



a

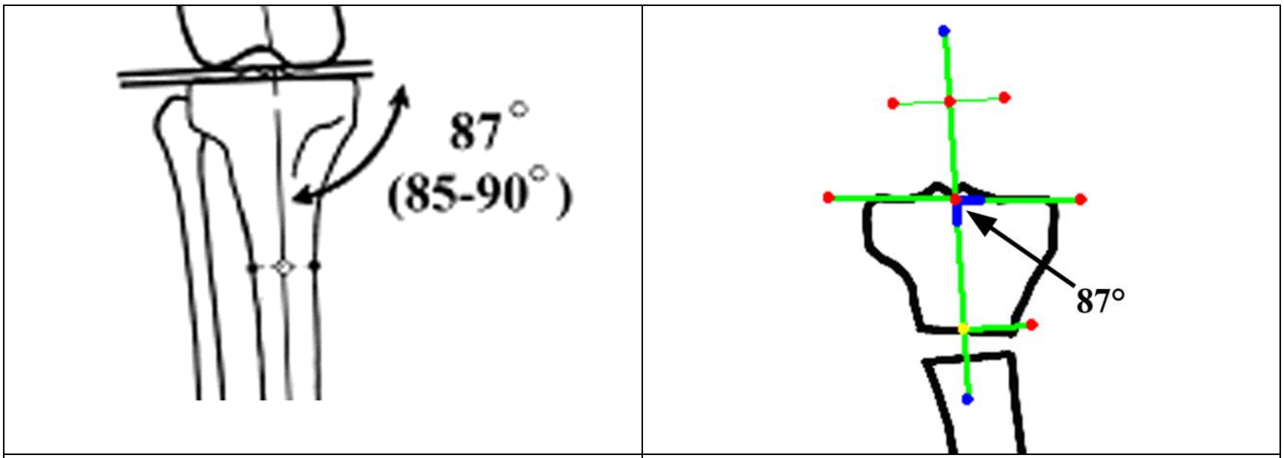


b

Fig. 60. Indicator of angle of axial line positioning (blue angle). **a** - centrator without blue angle must be moved out of bone fragment borders, so it is ignored. **b** - if necessary blue angle can be arranged to the right of axial line. For this purpose overlap cursor with left point of centrator and press the left button of the mouse. While left-clicking mouse, move this point left-to-right. As result blue angle meets the right position

The mechanical axis (as well as an anatomic axis) is known to cross a joint line in the certain point at the certain angle. Localization of crossing and value of an angle are specific for proximal and distal joints of each long bone in frontal and sagittal planes [Paley D., 2003; Solomin L.N., 2008, 2013]. With reference to Ortho-SUV software, centrator with blue angle is a joint line. Thus, to find a mechanical axis of a bone fragment, the centrator with blue angle must be placed in a projection of joint line. At the same time the vertex of the blue angle must be placed at a due point of crossing of the mechanical axis and the joint line. For this purpose red points of the centrator is moved in a necessary direction. After that necessary value of blue angle must be set. For this purpose there are fields “Blue angles on AP view” and “Blue angles on Lat view” in Step 10.

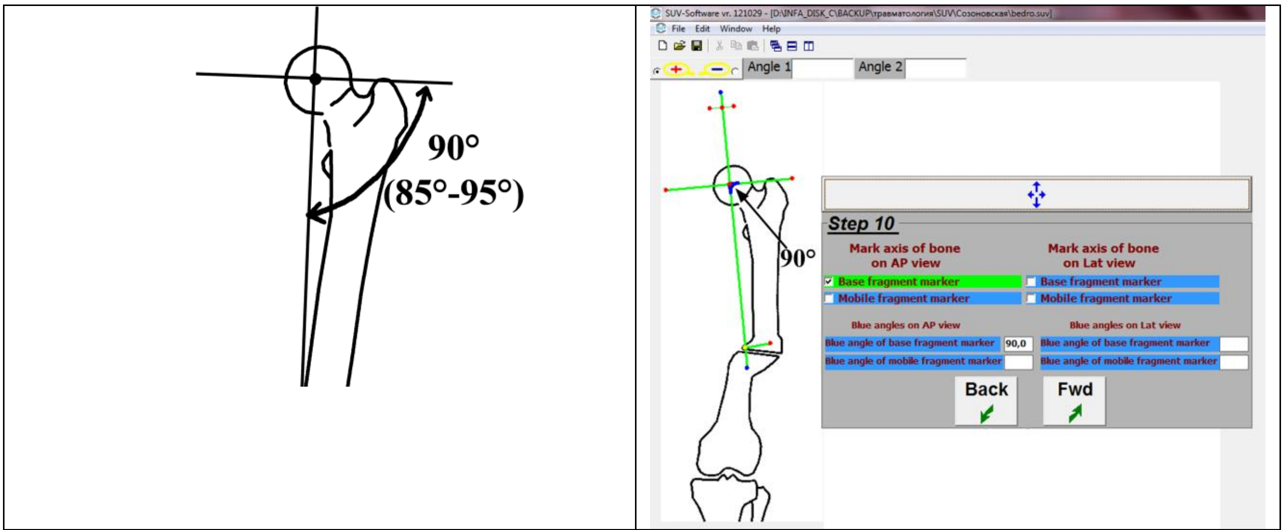
For example, it is known, that the proximal tibial mechanical angle in frontal plane is 87 deg., and the mechanical axis should cross the joint line in its centre. Moving with the help of the left-mouse extreme red points of the centrator, place the centrator to coincide with joint line and the vertex of the blue angle must be located in the centre of the joint line. After that in the field “Blue angle of base fragment marker” insert “87” and press the button “Blue angle of base fragment marker”. The axial line will be placed at an angle of 87 deg. to the centrator (joint line), designating the mechanical axis of the proximal fragment (Fig. 61).



a b

Fig. 61. Finding mechanical axis of proximal tibial bone in frontal plane with help of blue angle. **a** – diagram of mechanical angle. **b** – centrator with blue angle is placed on joint line and vertex of blue angle coincides with centre of joint line. Due value of blue angle 87 deg. is inserted. It leads to that axial line of green tree takes position of mechanical axis of bone fragment. Note, that yellow point is placed on distal border of proximal fragment

It is known, that the proximal femoral mechanical angle in frontal plane is 90 deg., and the mechanical axis should cross the joint line in the centre of femoral head. Moving with the help of the left-mouse extreme red points of the centrator, place the centrator to coincide with joint line and the vertex of the blue angle must be placed in the centre of femoral head. After that in the field “Blue angle of base fragment marker” insert “90” and press the button on “Blue angle of base fragment marker”. The axial line placed at an angle of 90 deg. to the centrator (joint line), designating the mechanical axis of proximal fragment (Fig. 62).

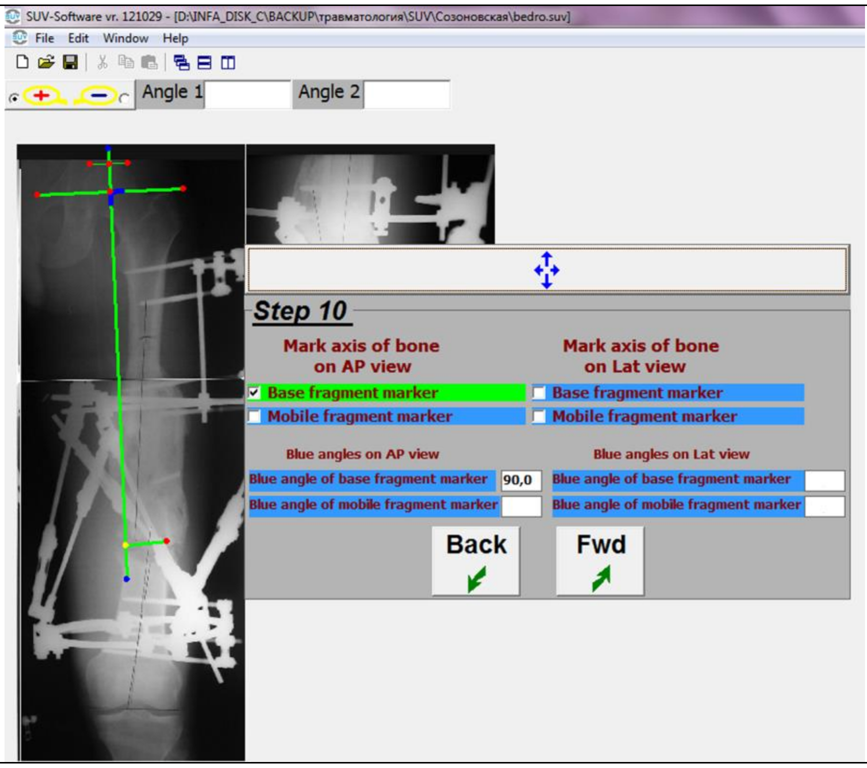


a b

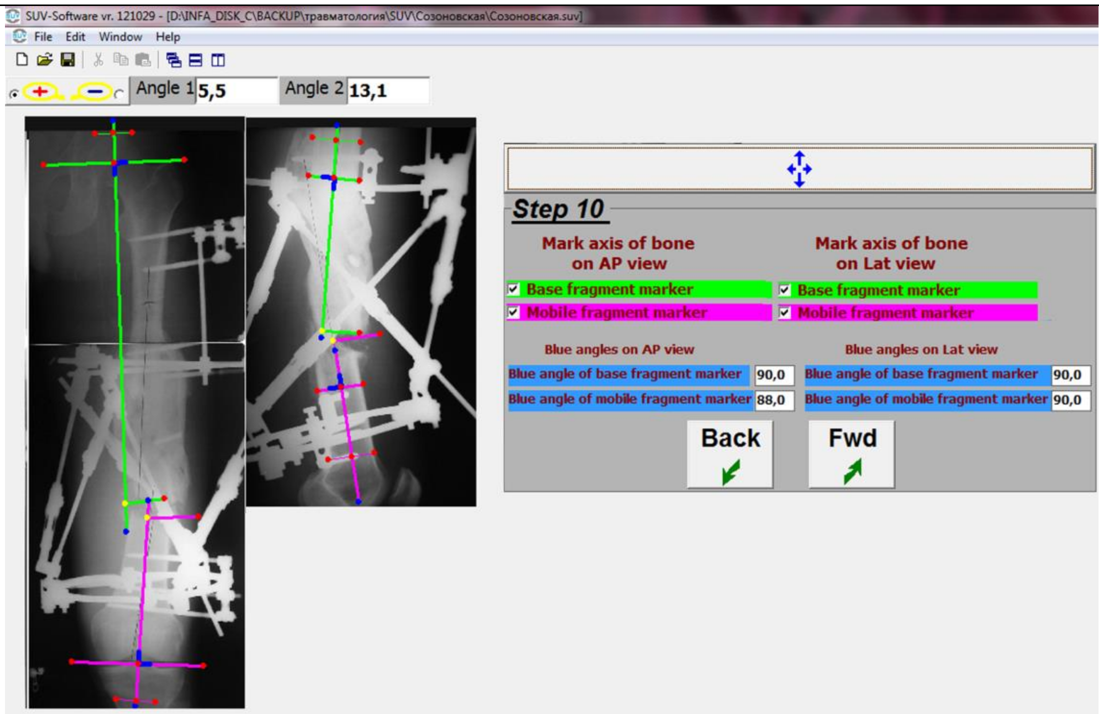
Fig. 62. Finding mechanical axis of proximal femoral bone in frontal plane with help of blue angle. **a** – diagram of mechanical angle. **b** – centrator with blue angle is placed on joint line and vertex of blue angle coincides with centre of femoral head. Due

value of blue angle 90 deg. is inserted. It leads to that axial line of tree takes position of mechanical axis of bone fragment. Note, that yellow point is placed on distal border of proximal fragment

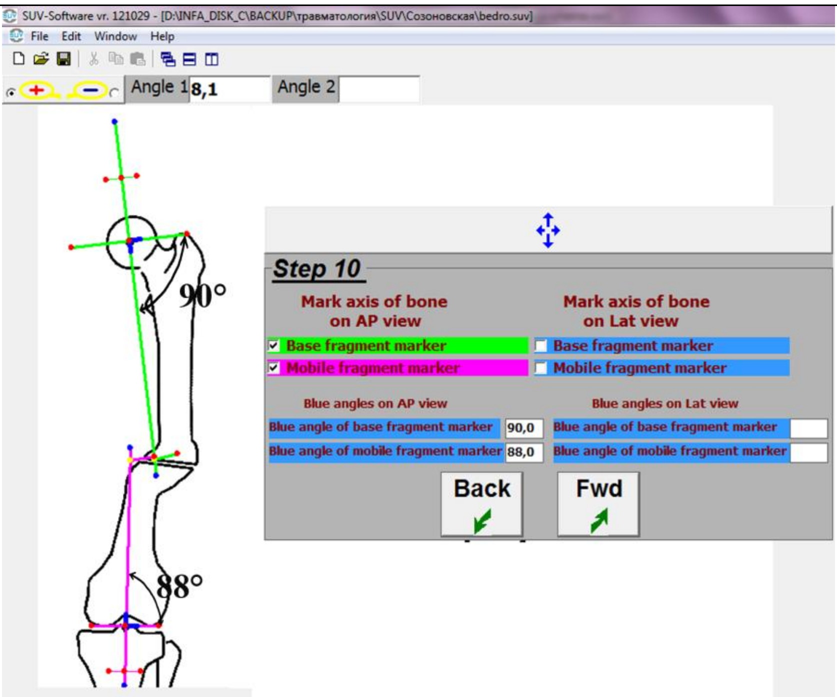
The Ortho-SUV software window in Step 10 at finding of mechanical axes of femoral fragments in frontal plane with the use of blue angle is shown in Fig. 63.



a



b



c

Fig. 63. The Ortho-SUV software window in Step 10 at finding of mechanical axes of femoral fragments in frontal plane with use of blue angle. **a** – centrator with blue angle is placed on joint line and vertex of blue angle coincides with centre of femoral head. Due value of blue angle 90 deg. is inserted in field “Blue angle of base fragment”. It leads to that axial line of tree takes position of mechanical axis of bone fragment. **b** – centrator with blue angle is placed on knee joint line and vertex of blue angle coincides with centre of joint line. Due value of blue angle 88 deg. is inserted in field “Blue angle of mobile fragment”. It leads to that axial line of violet tree takes position of mechanical axis of mobile fragment. Yellow points are placed on borders of proximal and distal fragments. For Lat view anatomic axes of fragments has been found with use of both centrators. **c -** diagram of finding mechanical axes of fragments in frontal plane

*Finding **anatomic axes** with the help of blue angle*

When the length of a bone fragment does not allow using centrators to find anatomic axis, the blue angle can be used.

The anatomic axis (as well as the mechanical axis) is known to cross a joint line in the certain point at the certain angle. Localization of crossing and value of an angle are specific for proximal and distal joints of each long bone in frontal and sagittal planes (Paley D., 2003; Solomin L.N., 2008, 2013). With the reference to Ortho-SUV software, centrator with the blue angle is a joint line. Thus, to define an anatomic axis of a bone fragment, centrator with the blue angle must be placed in a projection of joint line. At the same time the vertex of the blue angle must be placed at a due point of crossing of the anatomic axis and the joint line. After that necessary value of the blue angle must be set. For this purpose there are fields “Blue angles on AP view” and “Blue angles on Lat view” in Step 10.

For example, there is a supracondylar deformation of a femur. The length and the shape of distal fragment do not allow using the centrators. For example, it is known, that the distal femoral anatomic angle in sagittal plane is 83 deg., and the anatomic axis should cross the joint line at its anterior third. Moving with the help of the left-mouse extreme red points of the centrator, place the centrator to coincide with joint line and the vertex of the blue angle must be placed at the anterior third of the joint line. After that in the field “Blue angle of mobile fragment marker” insert “83” and press the button on “Blue angle of mobile fragment marker”. The axial line placed at the angle 83 deg. to the centrator (joint line), designating the anatomic axis of distal fragment (Fig. 64).

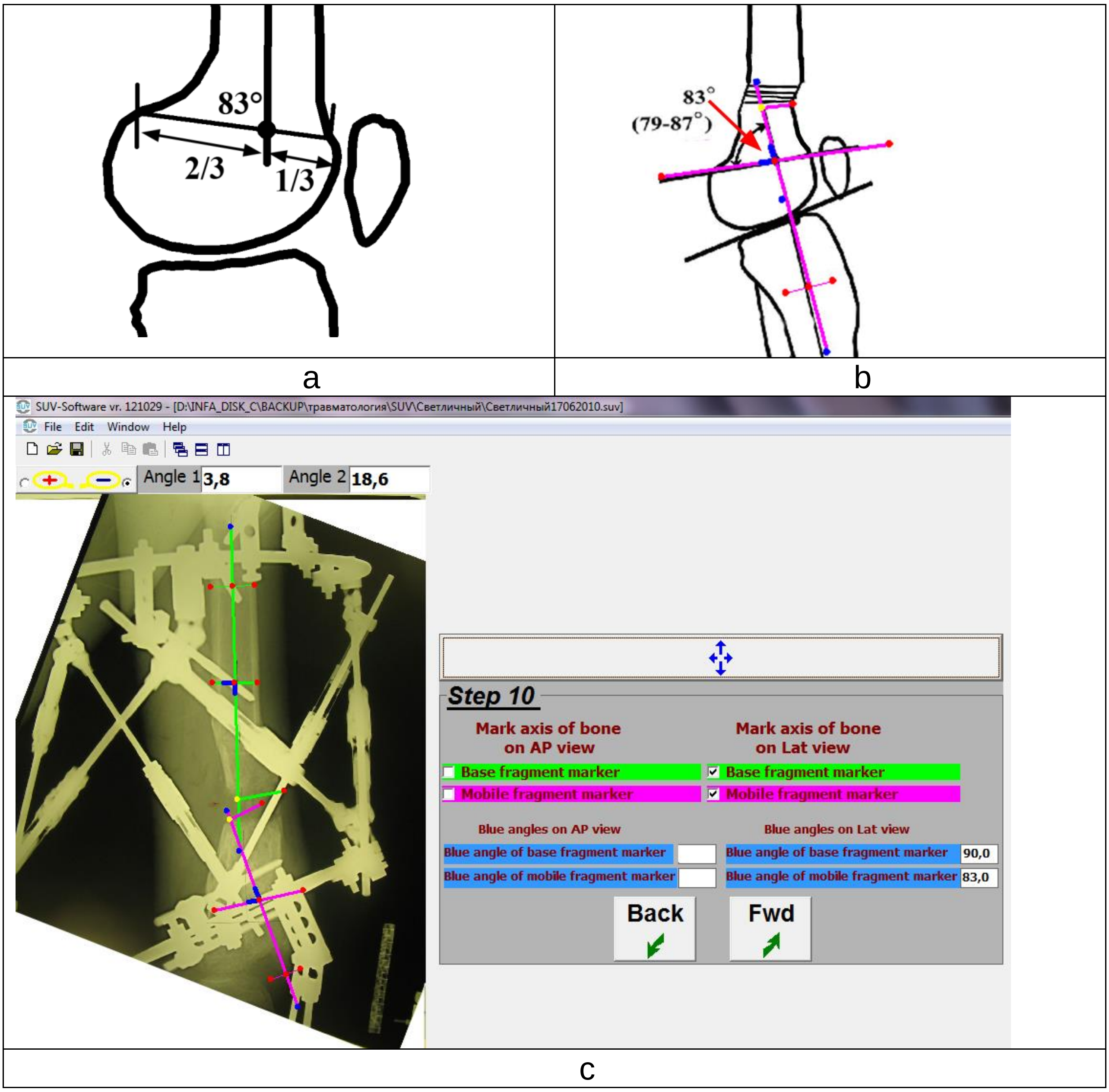


Fig. 64. Finding anatomic axis of distal femoral bone fragment in frontal plane with help of blue angle. **a** – diagram of anatomic angle. **b** - as bone fragment is short, centrators can not be used. Distal centrator is moved off border of distal fragment. Centrator with blue angle is placed on joint line and vertex of blue angle coincides with anterior third of joint line. Due value of blue angle 83 deg. is inserted. It leads to axial line of violet tree takes position of anatomic axis of bone fragment. Yellow point is placed on proximal border of distal fragment. **c** - software window at finding anatomic axes of femur in csagittal plane. Anatomic axis of proximal fragment is found with the help of centrators

Having placed the bone fragment markers, click on the “Forward” button to continue.

Step 11: Correction of the Final Position of the Mobile Fragment

After execution of Step 10 and clicking the "Fwd" button, in the field of roentgenograms yellow bone contours appear again. Let's remind that yellow bone contours are made in Step 8 and with their help the program designates *an initial position* of a mobile fragment. In addition it Step 11 *red bone contours* appear. By red bone contours the program designates *final position* of a mobile fragment after deformity correction or fracture reduction.

NB!

Yellow bone contours mean the initial position of the mobile fragment.
Red bone contours mean the final position of the mobile fragment.
To correctly estimate the position of red bone contours maximal magnification must be used.

If in Step 11 bone contours are invisible, it is necessary to press the right button of the mouse. It results in appearance of *the pop-up menu*. In the pop-up menu it is necessary to chose “Visibility of bone fragment contours” and to press the left button of the mouse. In addition, using this pop-up menu is possible to make markers of bone fragments (green and violet trees) visible, or, on the contrary, invisible. For this purpose the button “Visibility of bone fragment markers” should be used (Fig. 65).

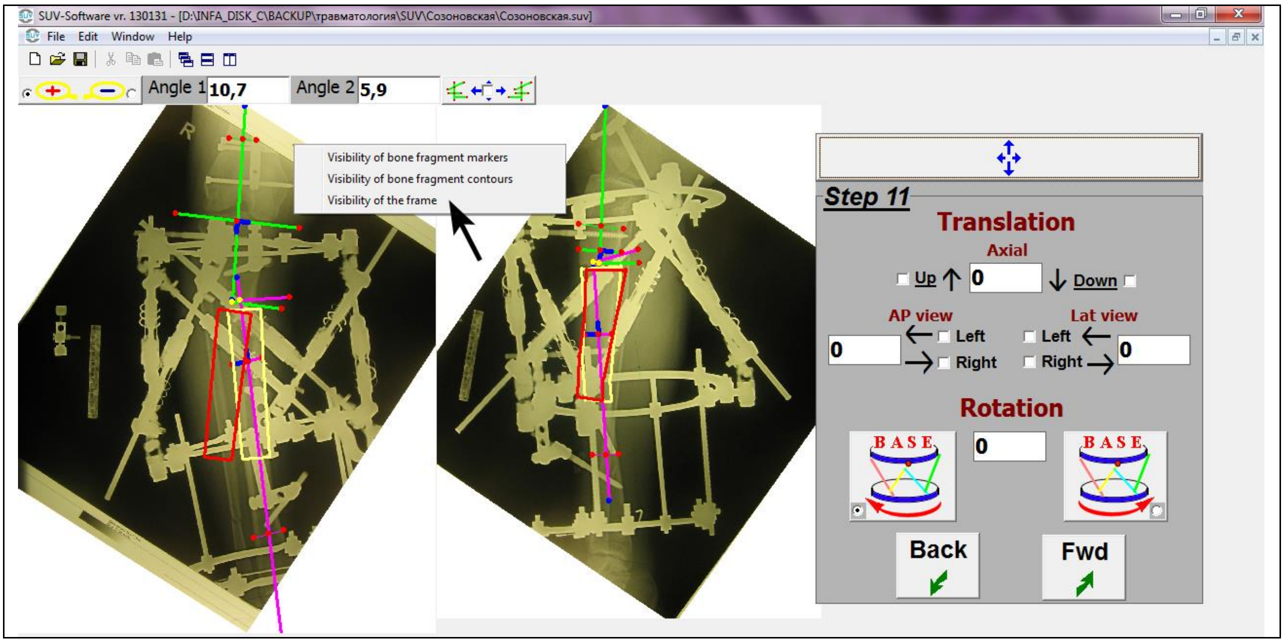


Fig. 65. Ortho-SUV program window in Step 11. There are bone fragment markers (trees) and yellow and red bone contours in field of roentgenograms. Yellow bone contours are initial position of mobile fragment; red bone contours are final mobile

fragment position. Pressing of right button of the mouse leads pop-up menu appearance (pointed by arrow)

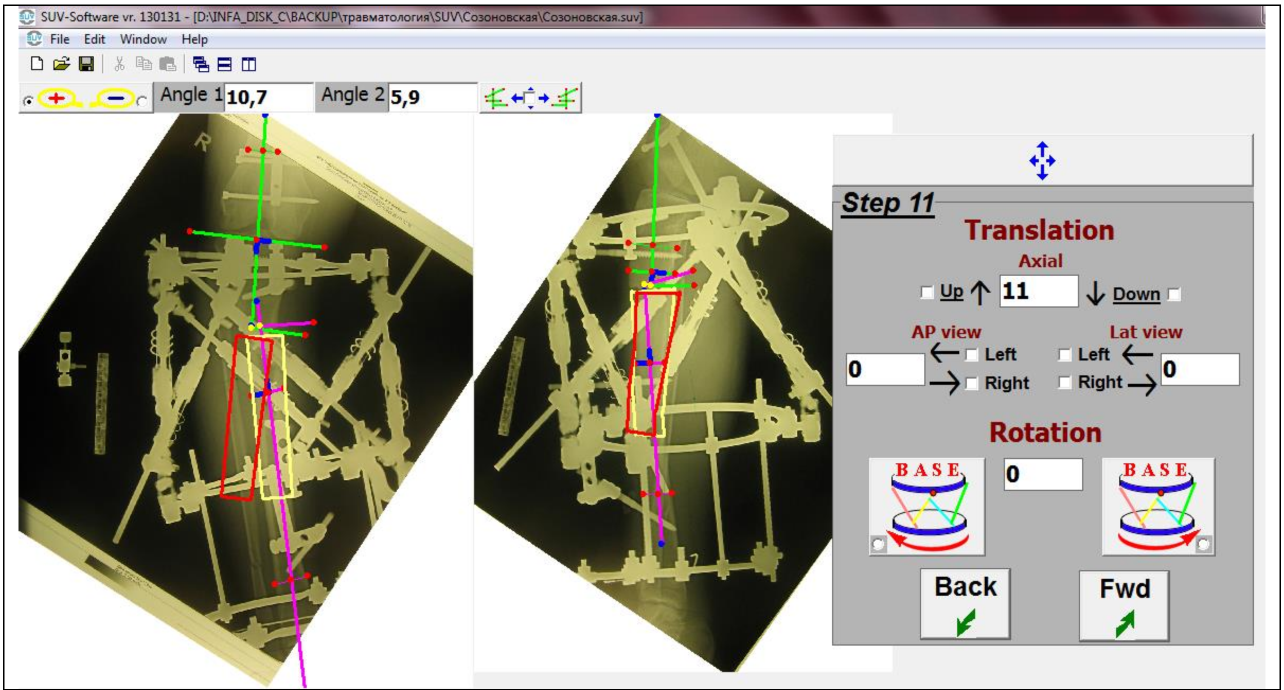
When the software user is satisfied with position of mobile fragment (position of red bone contours), he may pass to the following Step 12. When red bone contours have not the proper position, it is possible to correct it. The software options have capabilities to move red bone contours by necessary value upwards and downwards, to the left and to the right, angulate and rotate them as well.

<u>*Vertical and horizontal axial movings*</u>

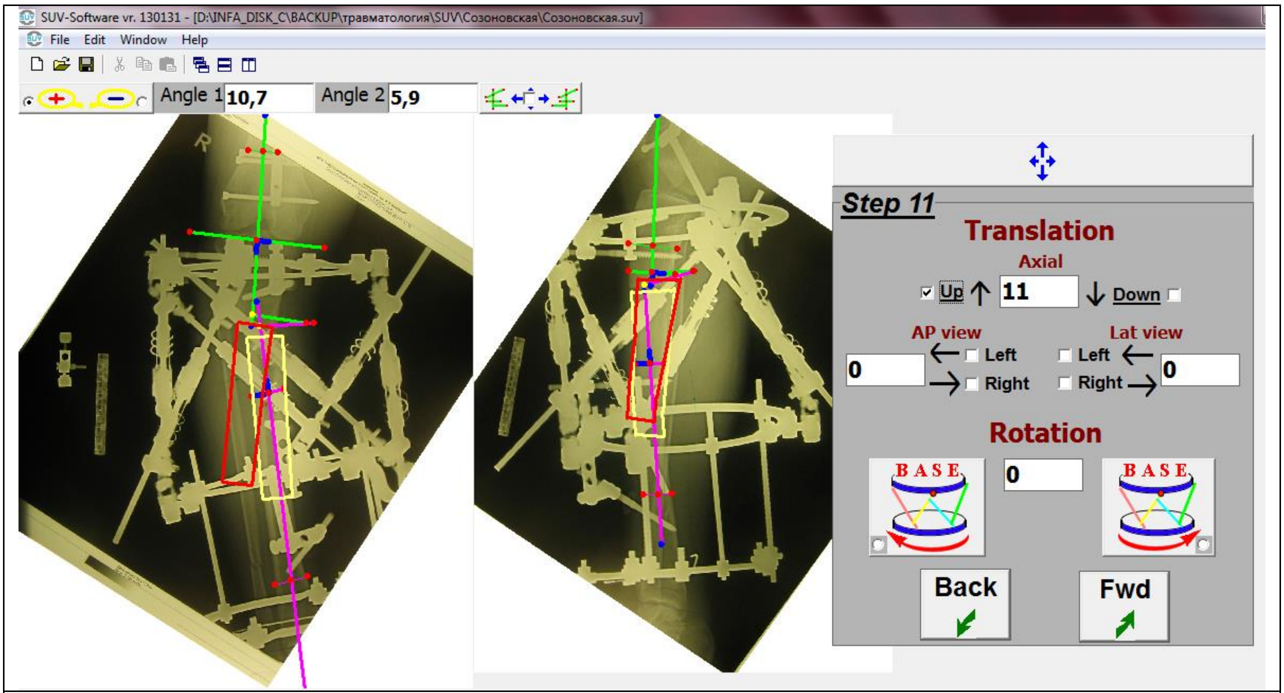
To move red bone contours *upwards*, it is necessary to insert the value of moving (in mm) and tick the window "Up". After that the red bone contours on both roentgenograms will move upwards by the given value. To move the red bone contours *downwards*, it is necessary to insert the value of moving (in mm) and tick the window "Down". After that red bone contours on both roentgenograms will move down by the given value (Fig. 66).

NB!

The axial moving up and down will take place along the axial lines of the basic bone fragments markers (axial lines of green trees).



a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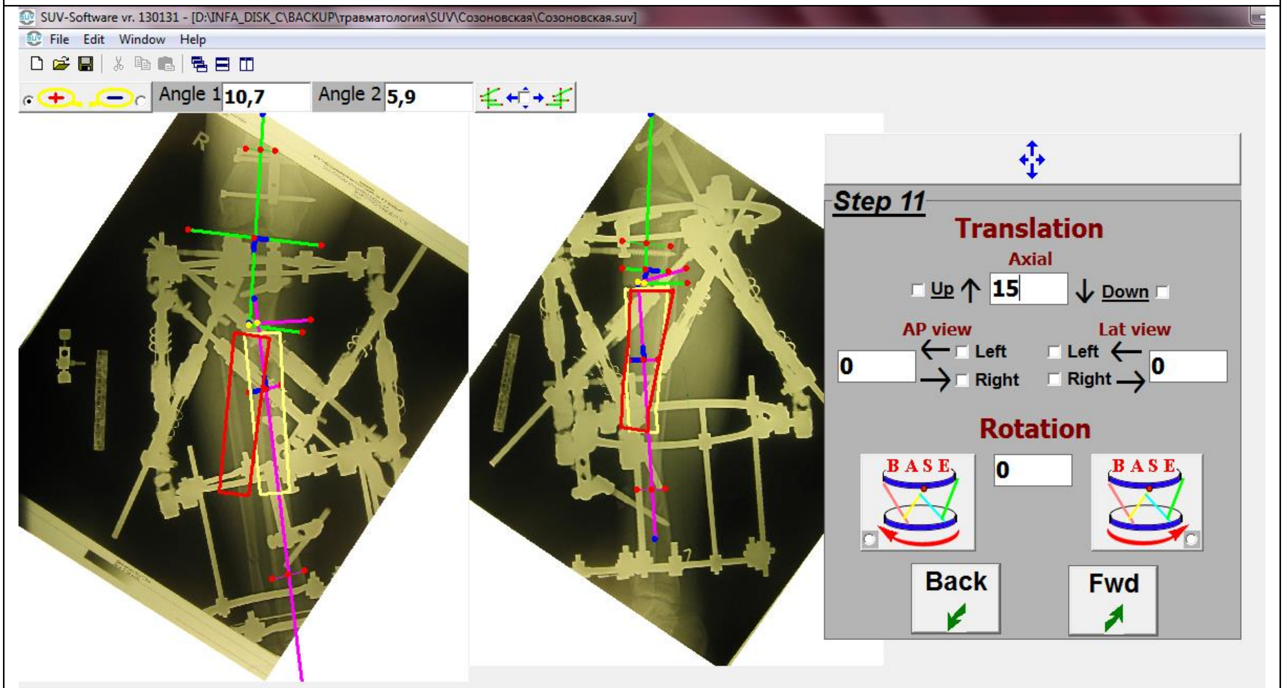
Angle 1 10,7
Angle 2 5,9
Step 11
Translation
Axial
Up 11 Down
AP view
Lat view
0 Left Right
Left Right 0
Rotation
BASE
0
BASE
Back
Fwd

b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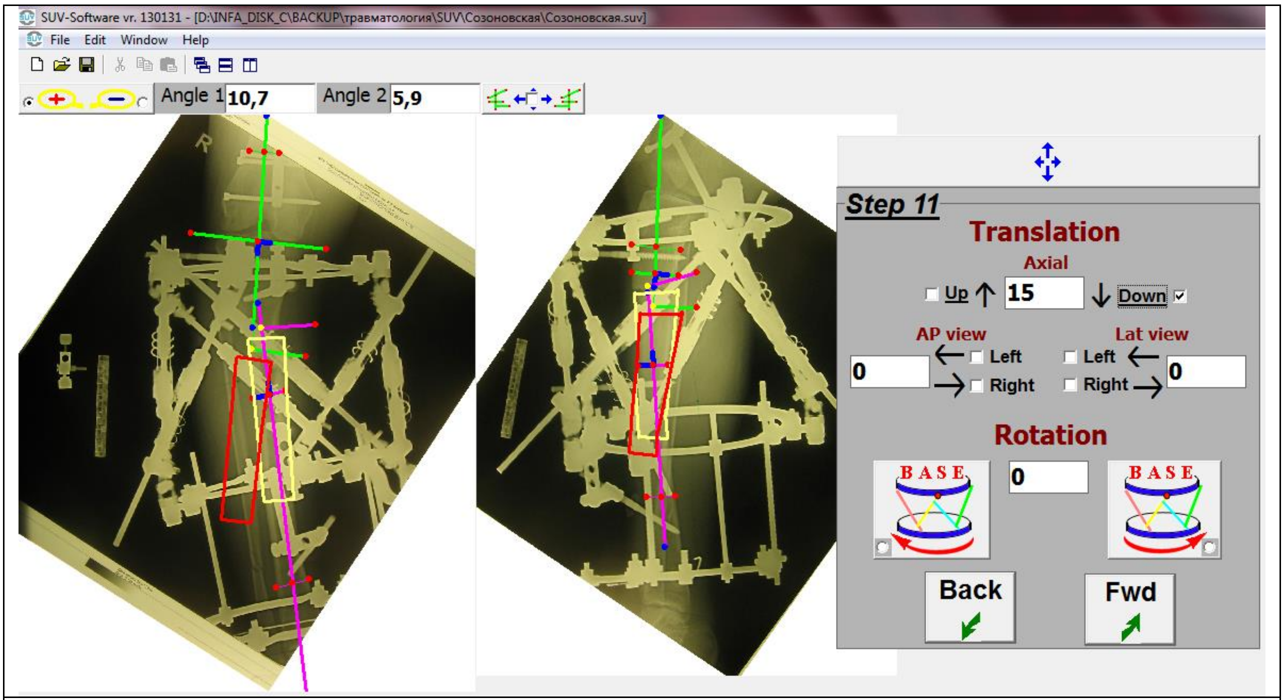
Angle 1 10,7
Angle 2 5,9
Step 11
Translation
Axial
Up 15 Down
AP view
Lat view
0 Left Right
Left Right 0
Rotation
BASE
0
BASE
Back
Fwd

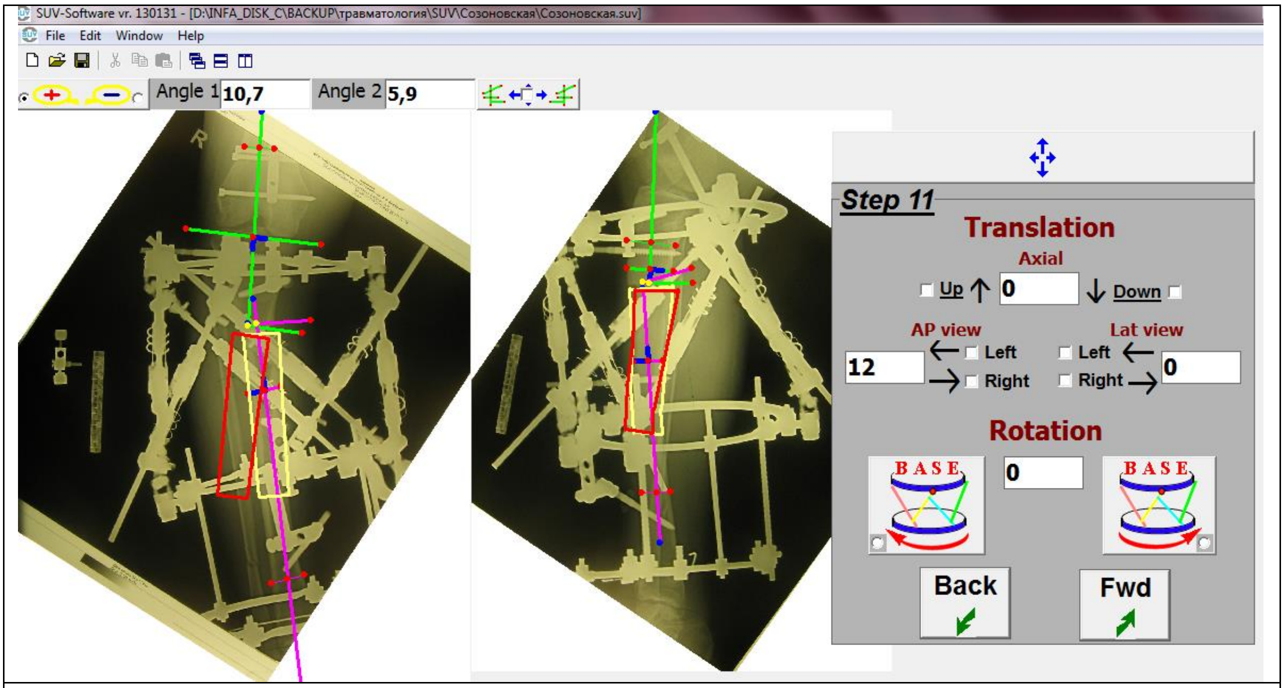
c



d

Fig. 66. Ortho-SUV program window in Step 11: vertical moving of red bone contours. **a** - necessary value is inserted into field of vertical moving - 11 mm. **b** - tick opposite "Up" is put. It has led to moving of red bone contours up. **c** - necessary value is inserted into field of vertical moving - 15 mm. **d** - tick opposite "Down" is put. It has led to moving of red bone contours downwards

To move red bone contour on the AP view *to the left*, it is necessary to insert the value of moving (in mm) and put a tick in the window "Left". After that red bone contour on the AP view will move to the left by the given value (Fig. 67). To move red bone contour *to the right*, the tick should be inserted in the window "Right". Red bone contour on the lateral view is moved in a similar way. The field “Lat view” must be used.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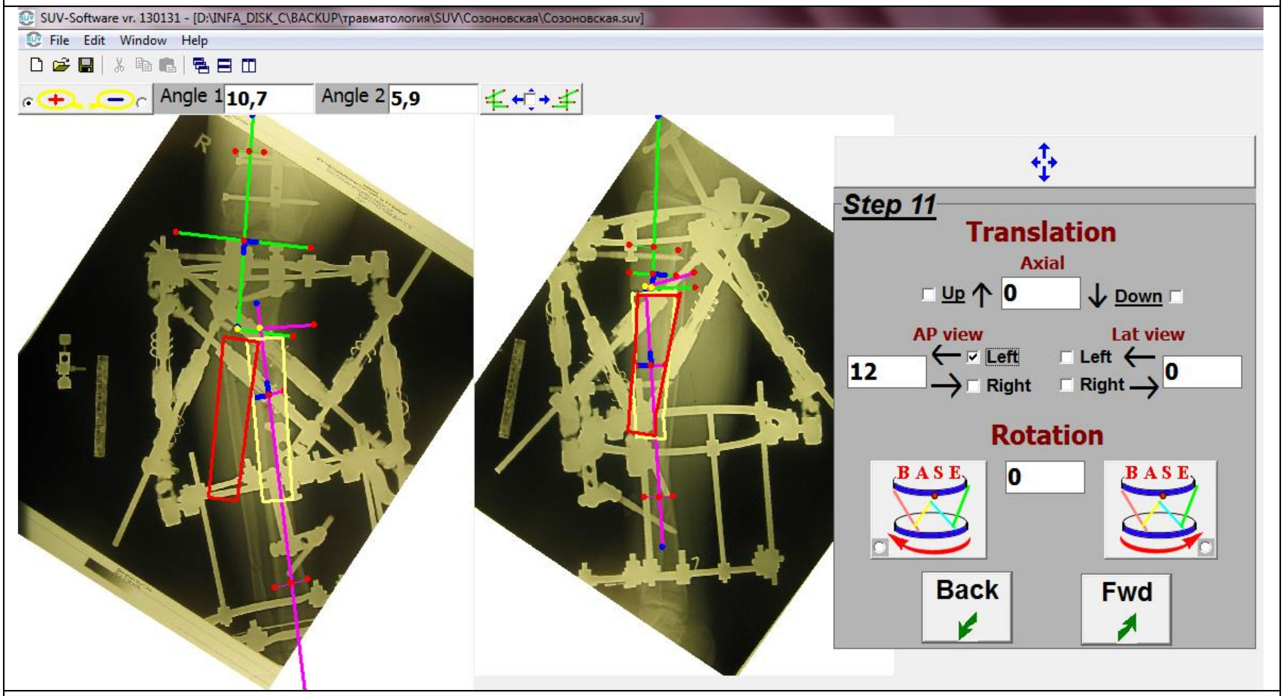
Angle 1 10,7
Angle 2 5,9
Step 11
Translation
Axial
Up
0
Down
AP view
Lat view
12
Left
Right
Left
Right
0
Rotation
BASE
0
BASE
Back
Fwd

a


SUV-Software vr. 130131 - [D:\INFA_DISK_C\BACKUP\травматология\SUV\Созоновская\Созоновская.suv]
File Edit Window Help
Angle 1 10,7
Angle 2 5,9
Step 11
Translation
Axial
Up
0
Down
AP view
Lat view
12
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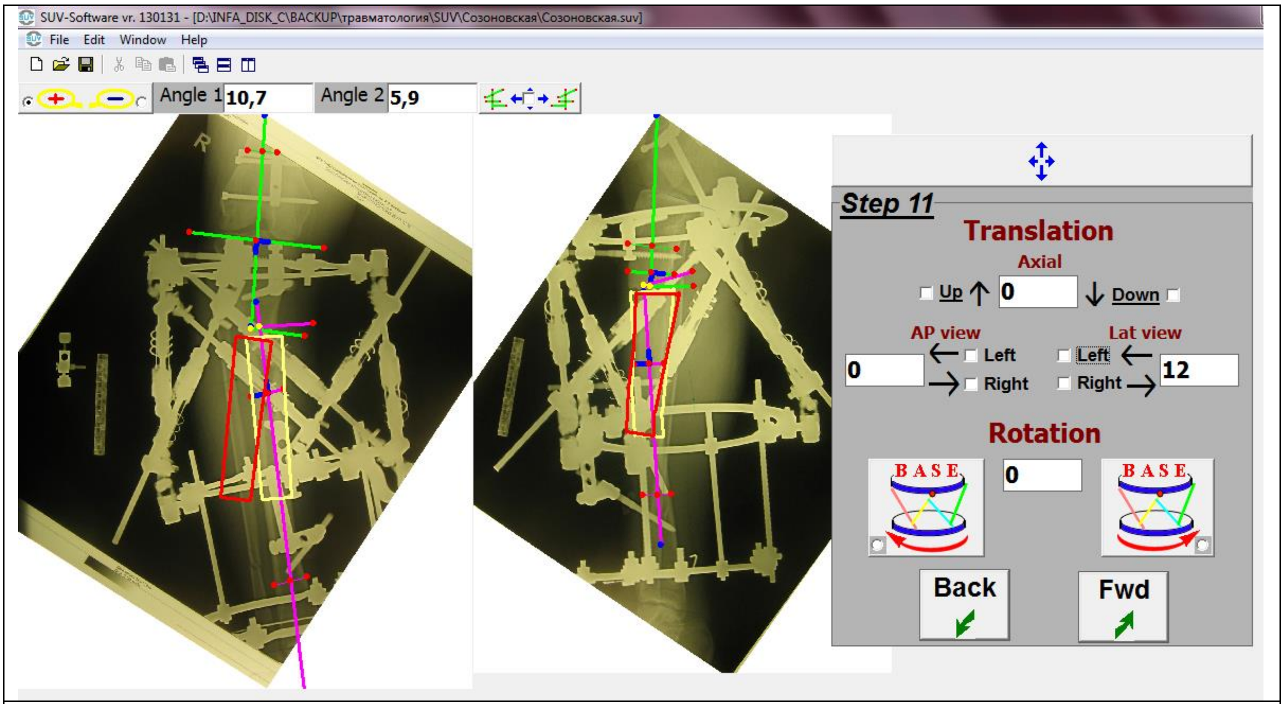
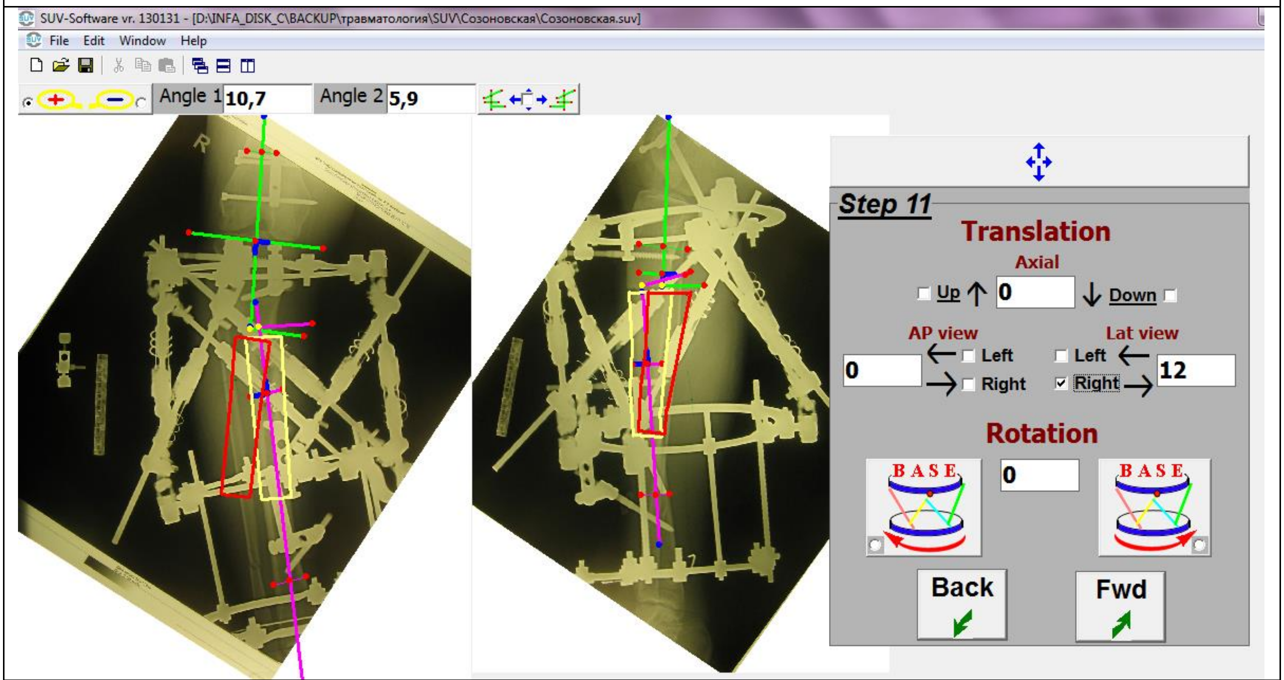
0
BASE
Back
Fwd

b



c



d

Fig. 67. Ortho-SUV program window in Step 11: horizontal moving (translation) of red bone contour. **a** - necessary value (11 mm) of translation is inserted into field “AP view”. **b** - button “Left” is clicked. It has led to moving of red bone contour to the left on AP view. Note, that "to the left" in this case means "inwards". **c** - necessary value (14 mm) of horizontal moving is inserted into field “Lat view”. **d** - button “Right” is clicked. It has led to moving of red bone contour to the right on Lat view. Note, that "to the right" in this case means "back"

NB!

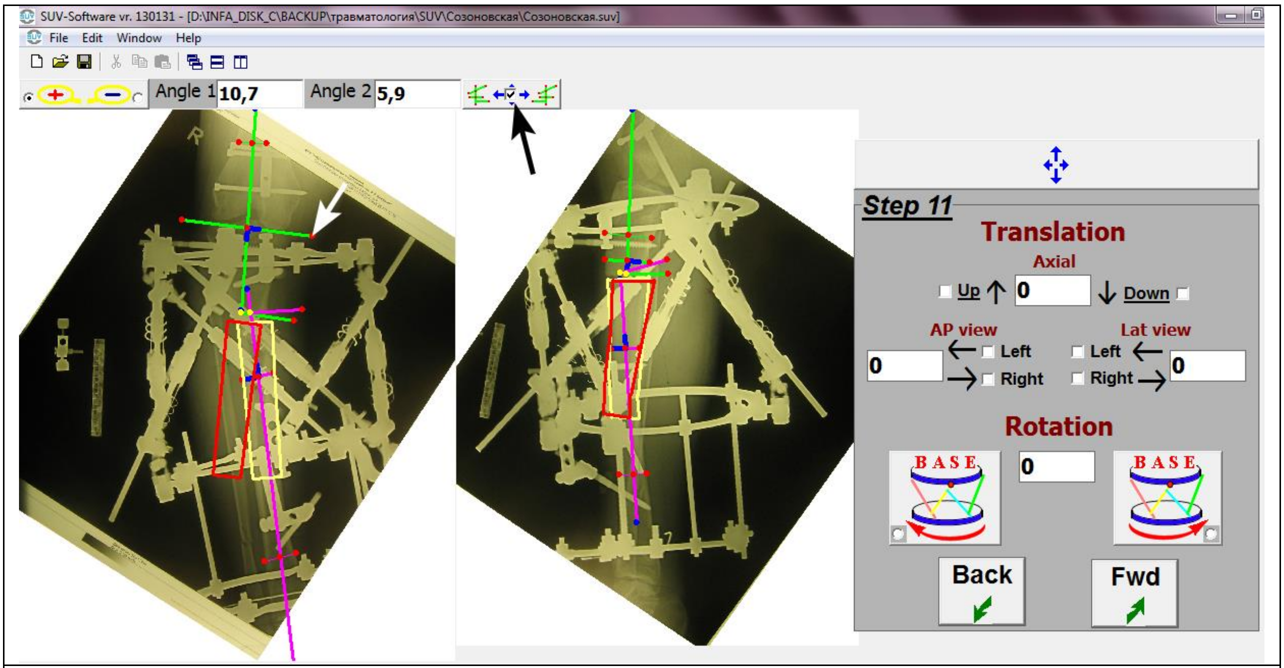
If X-ray examination have been made not strictly in tangential projections, i.e. not at an angle of 90 deg. to each other, transversal moving of red bone contour in one plane (for example, in AP view) will lead to some displacement of red contour in the second plane (in the field of the lateral view).

<u>Free plane-parallel moving of red bone contour</u>

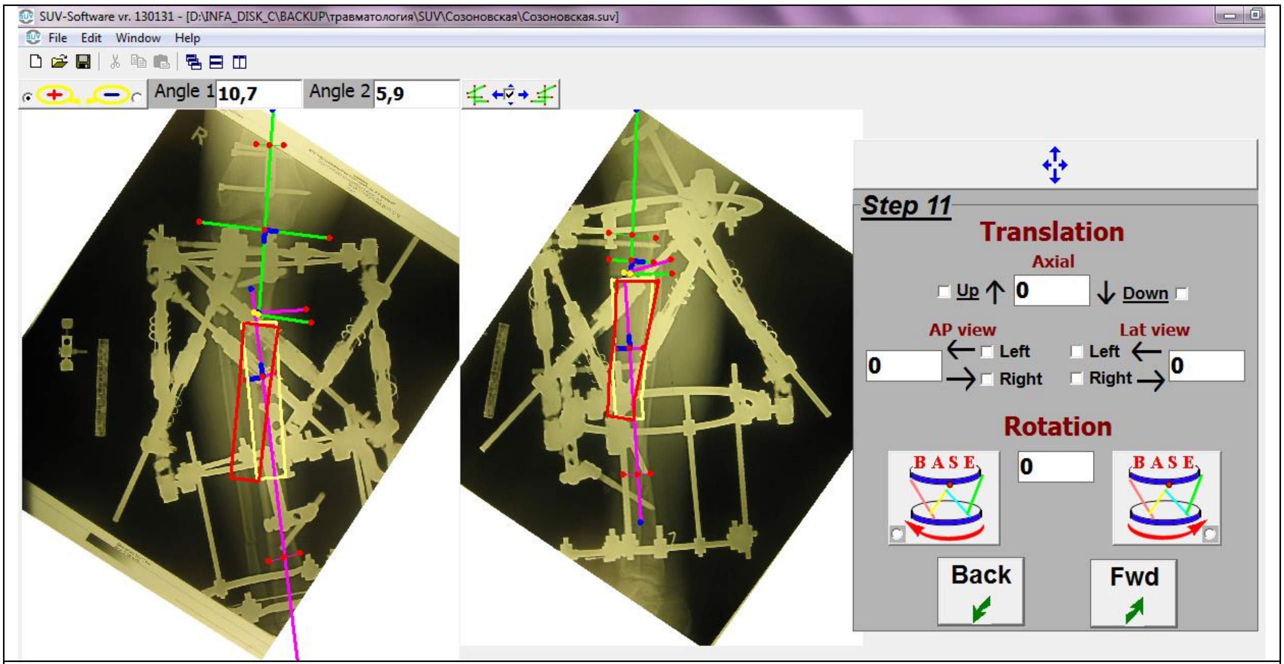
There is a button "plane-parallel moving" in the panel of tools in Step 11. Tick here. Then, having placed the cursor with any of red points of the marker of proximal bone fragment (green tree), while left-clicking the mouse, move the cursor on the screen. Red bone contour will move together with the cursor (Fig. 68). Note, that red bone contours change their position on both roentgenograms.

NB!

After necessary plane-parallel moving of red bone contour do not forget to remove the "tick" from the button "plane-parallel moving".



a



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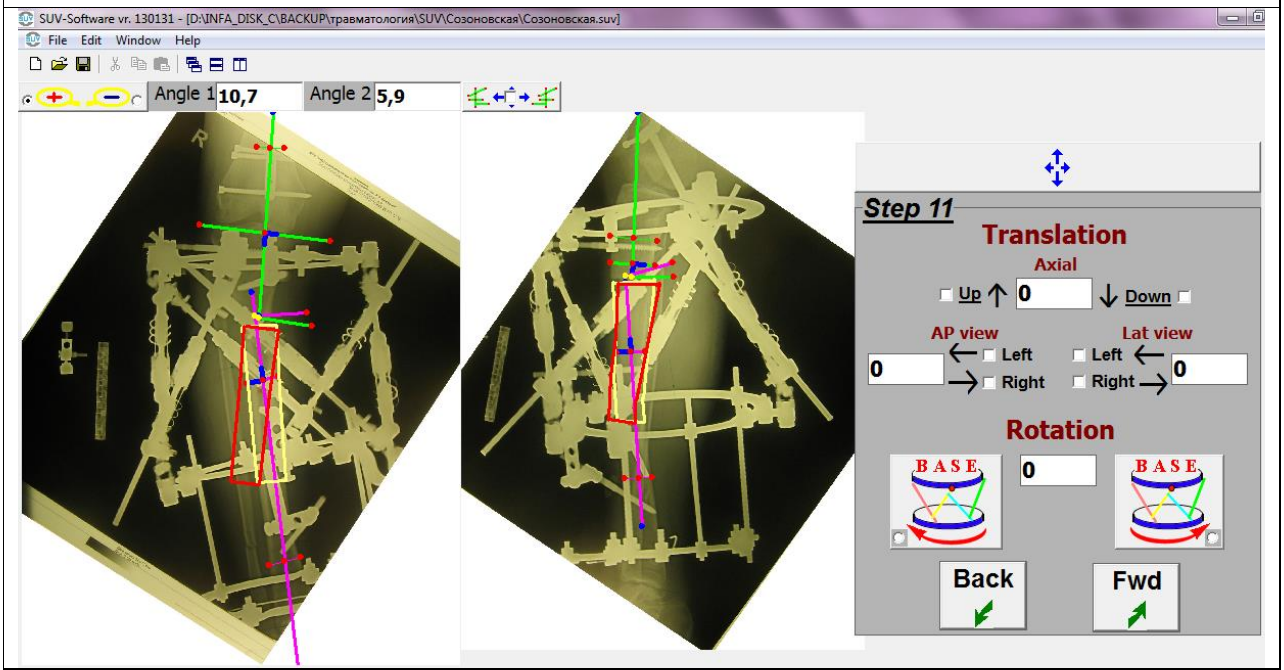


c

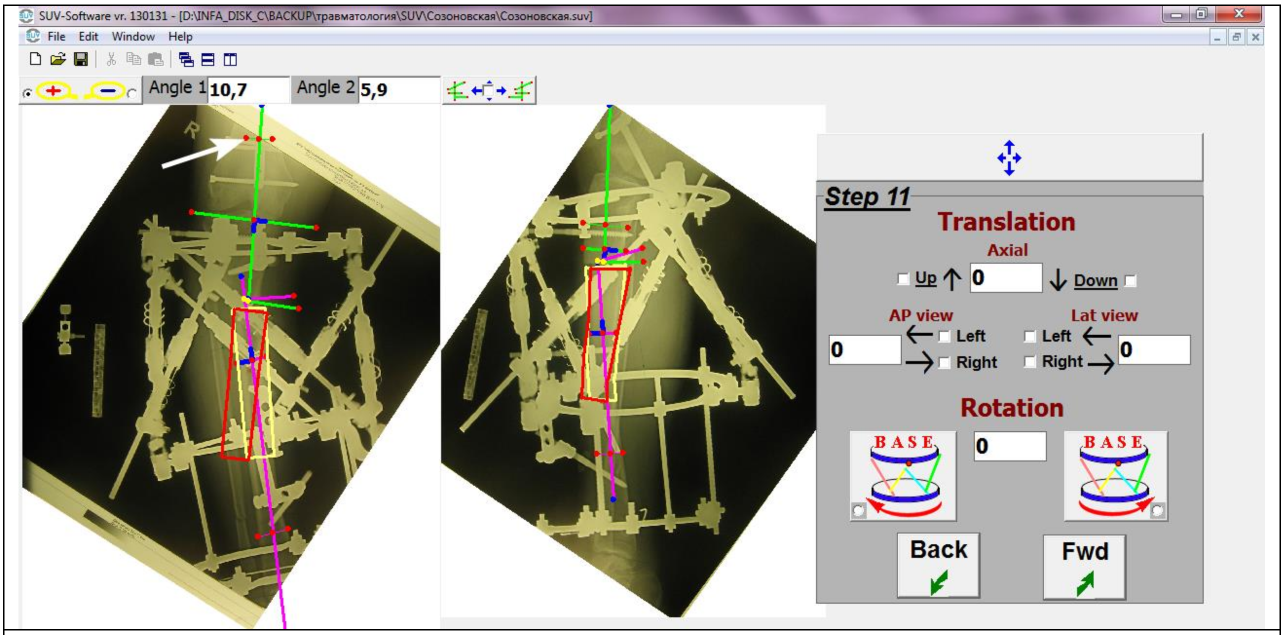
Fig. 68. Ortho-SUV program window in Step 11: free plane-parallel moving of red bone contour. **a** - button “plane-parallel moving” is ticked. The cursor is placed at one of red points (any can be used) of proximal fragment marker – green tree (pointed by arrow). **b** – while pressing left button of mouse red contour is moved to necessary position. **c** - "tick" in the button “plane-parallel moving” is being removed

Red bone contour angulation

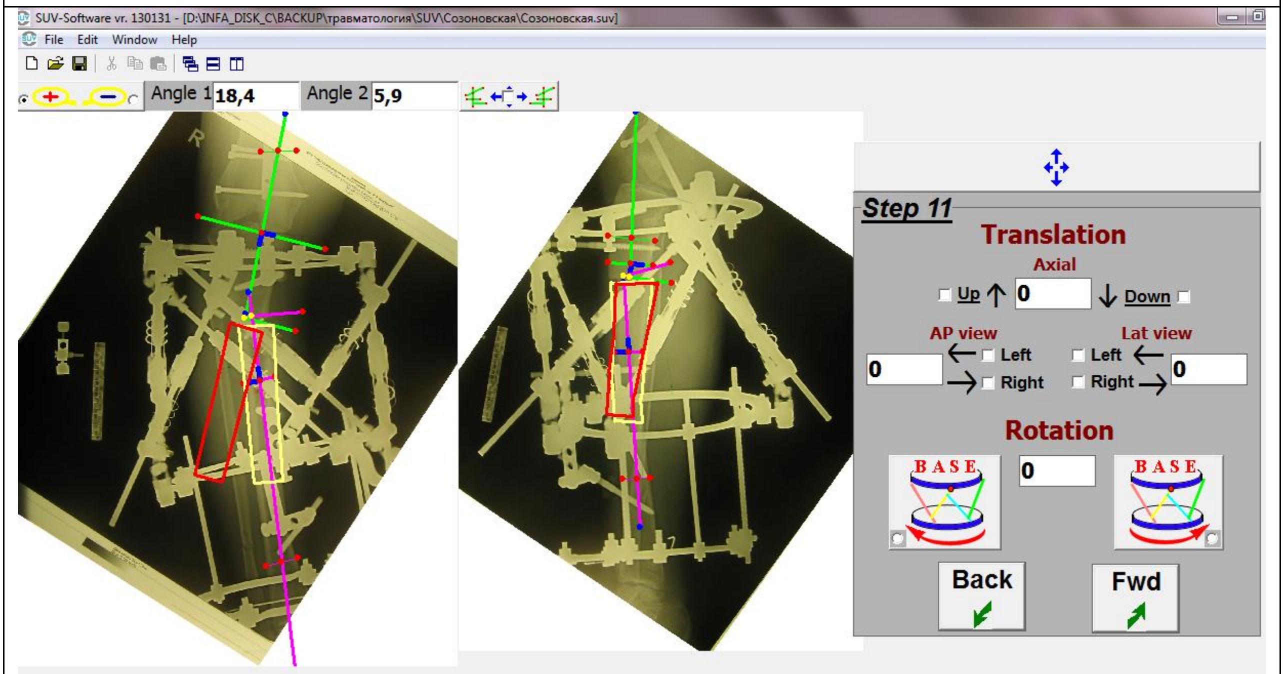
In Step 11 the fields “Angle 1” and “Angle 2” show the angles between the axial lines of the basic and mobile bone fragments markers: “Angle 1” for the AP view and “Angle 2” for the lateral view. These values can be used as reference points for necessary turn (angulation) of red bone contour.

For red bone contour angulation any of red points of the proximal bone fragment marker (green tree) can be used. It is most convenient to use the red points which are placed on the axial line of green tree. Place the cursor at any of these points and while keeping the left button of the mouse pressed, move the cursor on the screen. Red bone contour will move with the cursor together (Fig. 69). By experimentally changing points, achieve necessary position of red bone contour.

Note, that red contours change the position on both roentgenograms.



a



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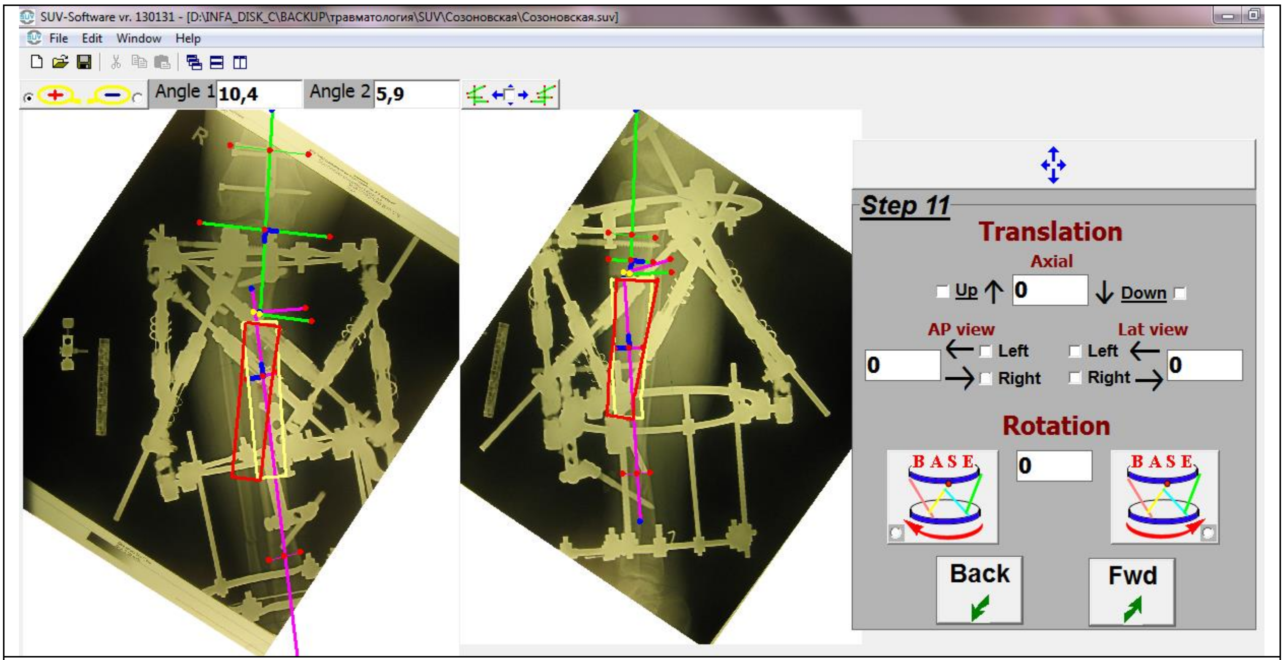
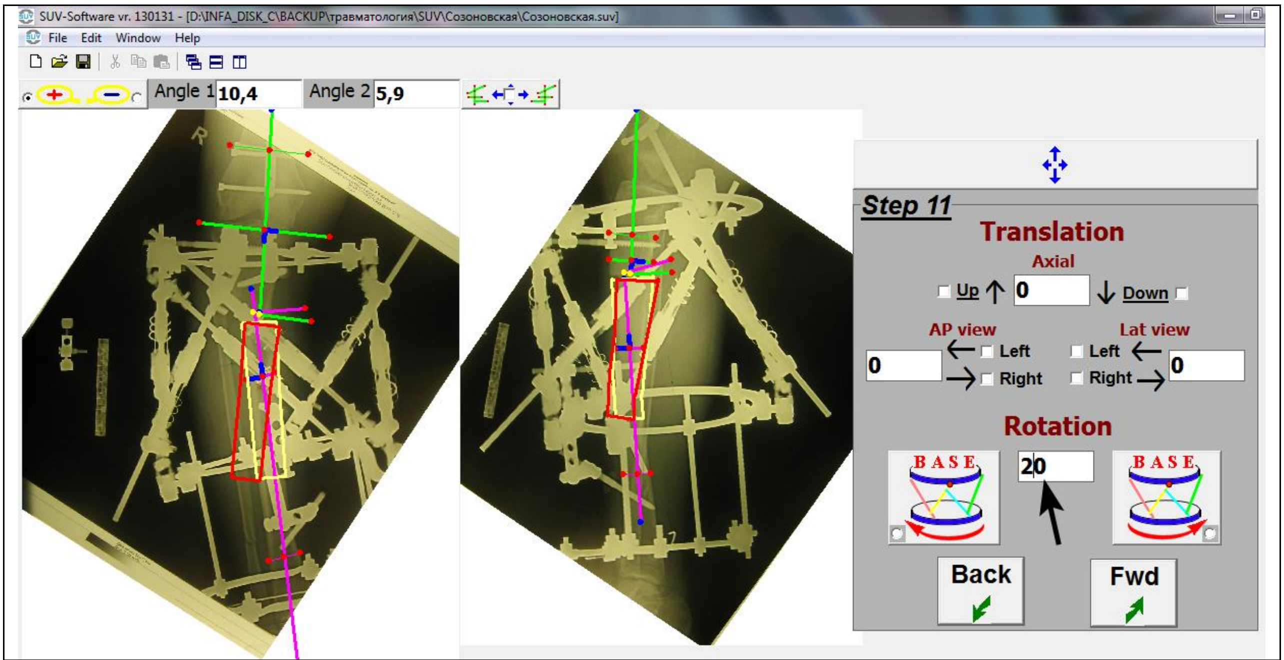


c

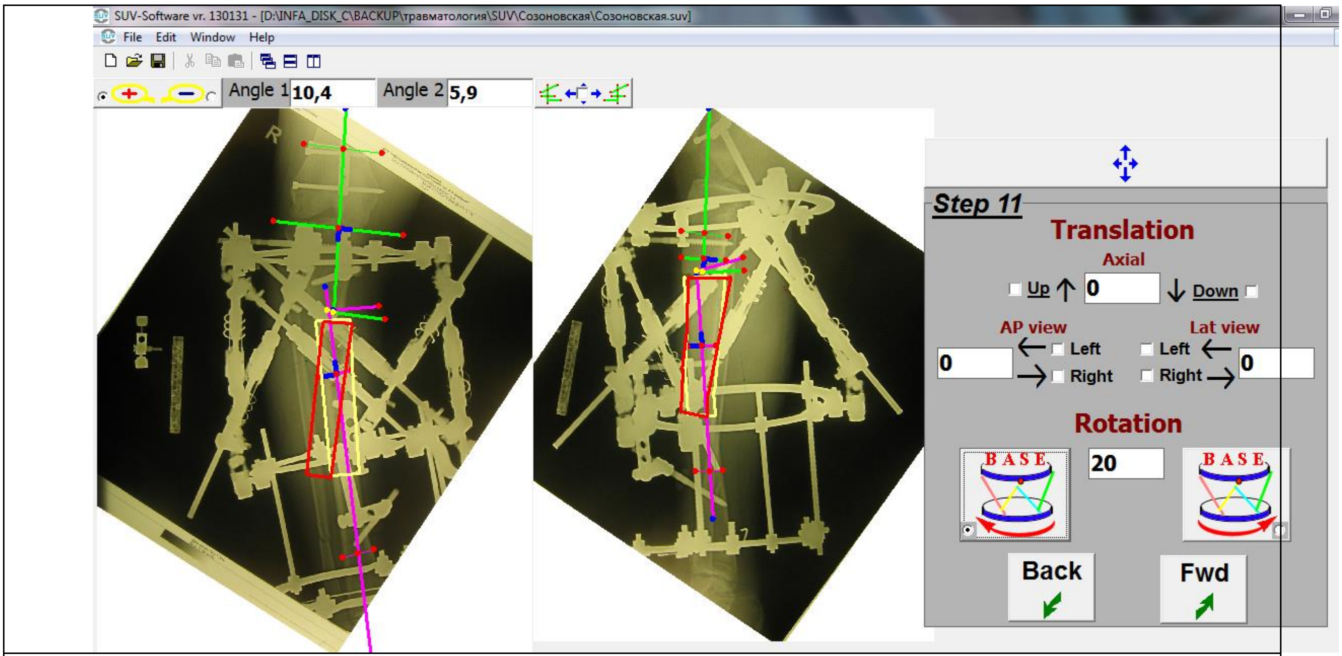
Fig. 69. Ortho-SUV program window in Step 11: red bone contour angulation. **a** - cursor is placed at one red points (any can be used) of proximal bone fragment marker (green tree) – pointed by arrow. **b** - while pressing left button of the mouse chosen red point is being moved. It leads to angulation of red bone contour. **c** - by experimentally changing red points necessary position for red bone contour is being achieved

Rotation

To rotate the mobile bone fragment (red bone contour) it is necessary to insert necessary value of rotation into appropriate window. After that it is necessary, using the left button of the mouse, to tick in the field: “Rotation to the left” or “Rotation to the right” (Fig. 70).



a

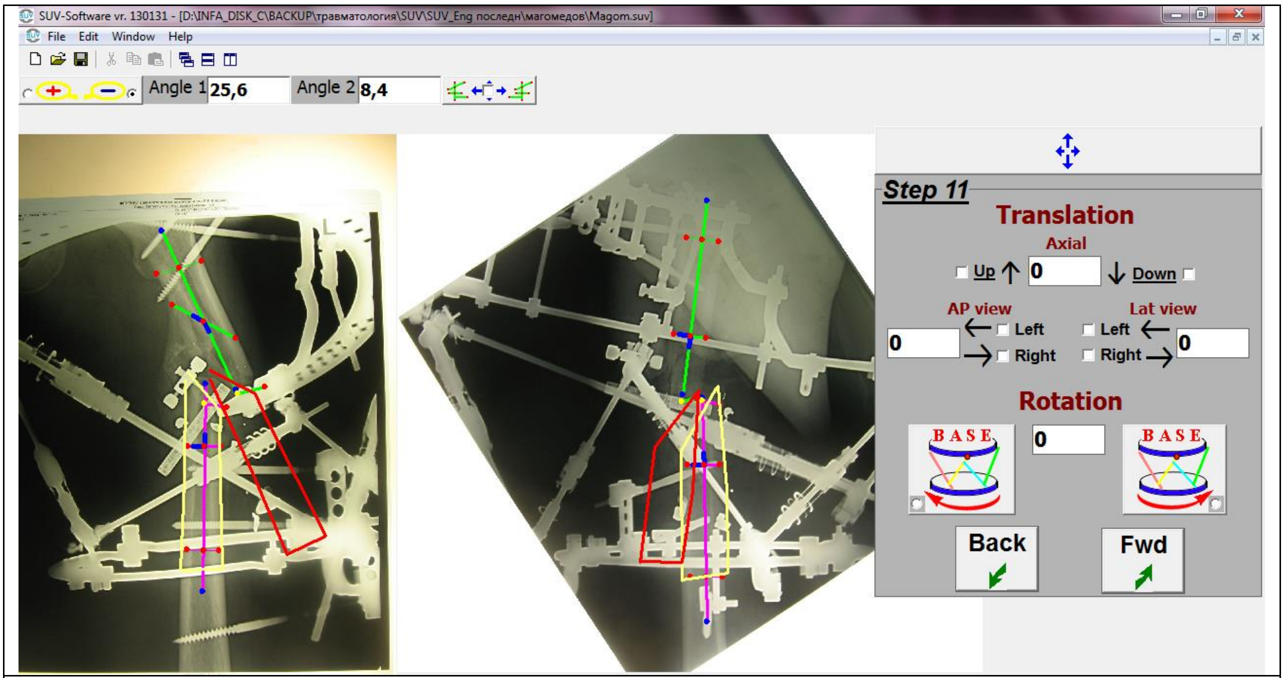


b

Fig. 70. Ortho-SUV program window in Step 11: rotation of mobile fragment. **a** – value of necessary rotation, 20 deg., is being entered into field "Rotation" (specified by arrow). **b** - field “rotation to the left” is being ticked. It has resulted to that the form and the sizes of both red bone contours changed

NNB!

It is necessary to take into consideration, that the program calculates moving of mobile bone fragment from an initial position to final one using the shortest trajectory - directly from "point A" to "point B". Therefore at overlapping of bone fragments it is necessary to execute reduction in two stages. The first stage is distraction to achieve 3-4 mm gap between fragments. The second stage is residual deformity correction. If not to do it, fragments "will be linked" and reduction becomes impossible (Fig. 71).



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Angle 2 8,4
Step 11
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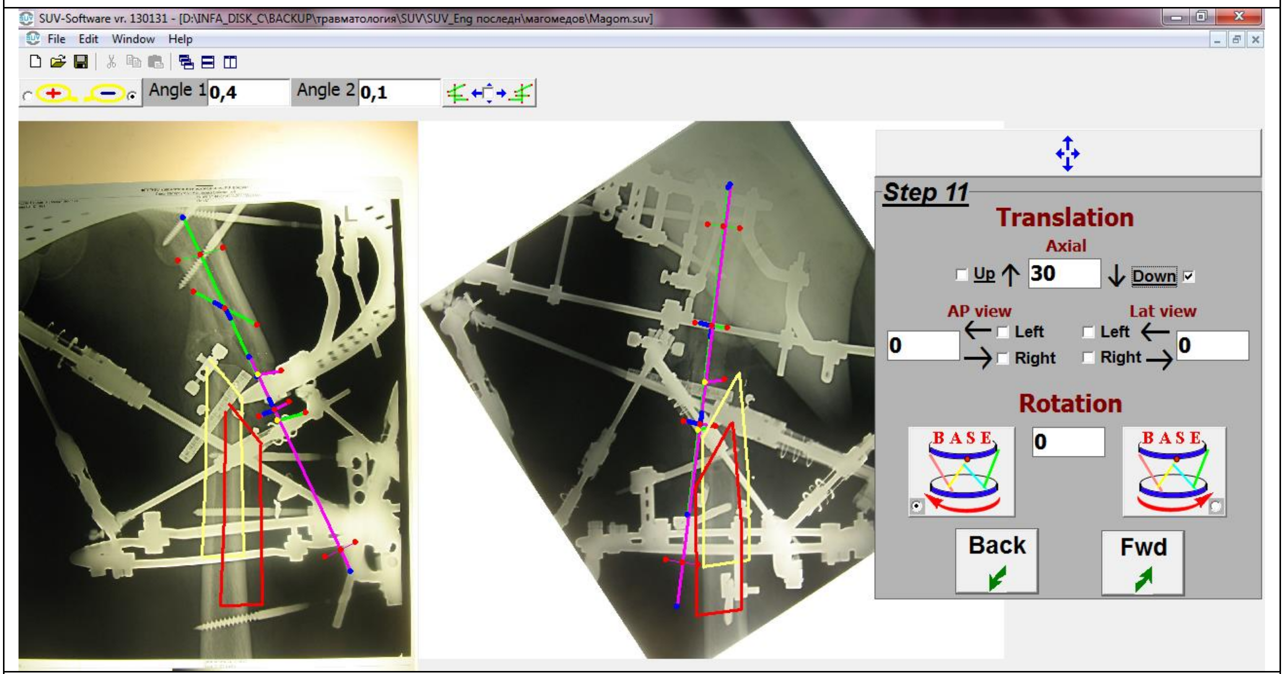
Axial
Up 0 Down
AP view
Lat view
0 Left Right
Left Right 0
Rotation
BASE
0
BASE
Back
Fwd

a



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Angle 2 0,1
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AP view
Lat view
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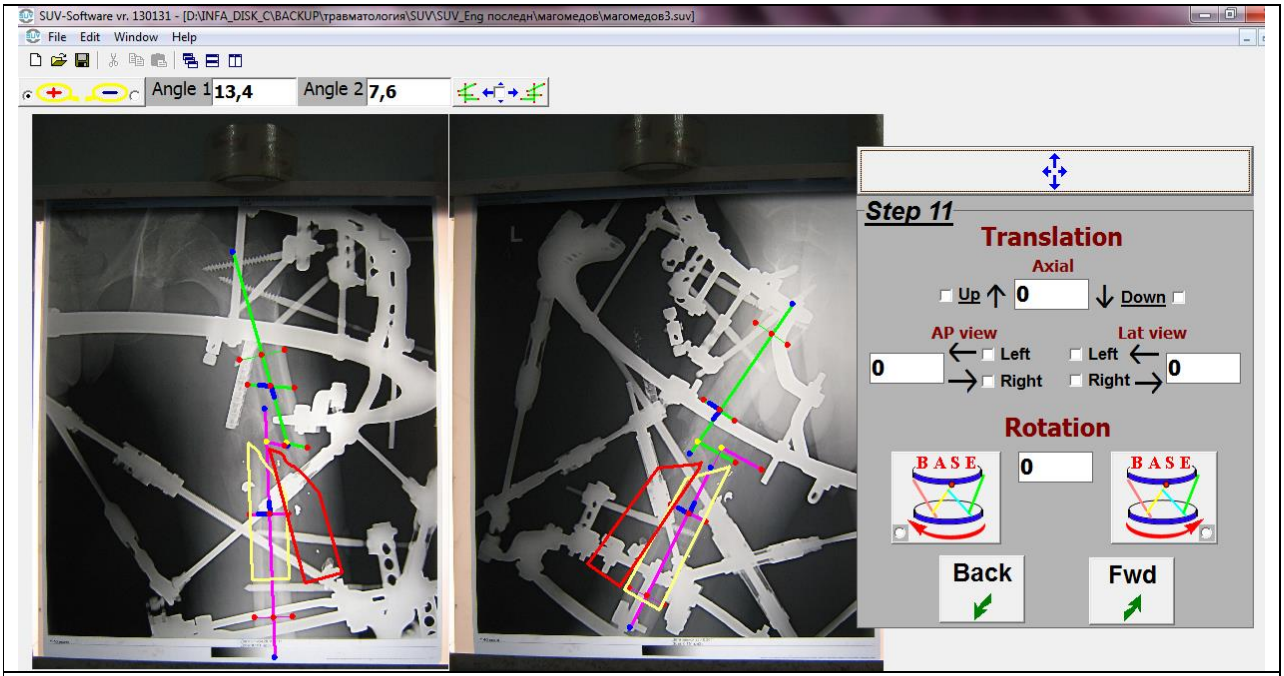
0
BASE
Back
Fwd

b



c

Fig. 71. Software calculates moving of mobile fragment on the shortest trajectory - "directly". **a** - moving on the shortest trajectory fragments will be linked and reduction becomes impossible. **b** - at fragments overlapping it is necessary, at first stage, to perform distraction to achieve 3-4 mm gap between fragments. **c** - after gap has appeared total residual correction can be done

NB!

Before Step 12 position of the red bone contour must be controlled using maximal magnification. A little residual displacement or possibility of "linking" of bone fragments can not be noticed at small magnification.

If options “Plane-parallel moving” and (or) “Angulation” have been used, the command “*to confirm moving*” (in the accepted slang - “to click the pointer”) must be done before going to Step 12. To do this it is necessary to place the cursor at the red point connected to the yellow point (index of border of proximal bone fragment) in a lateral view and press the left button of the mouse. After that confirm moving of mobile fragment by clicking the pointer (Fig. 72).

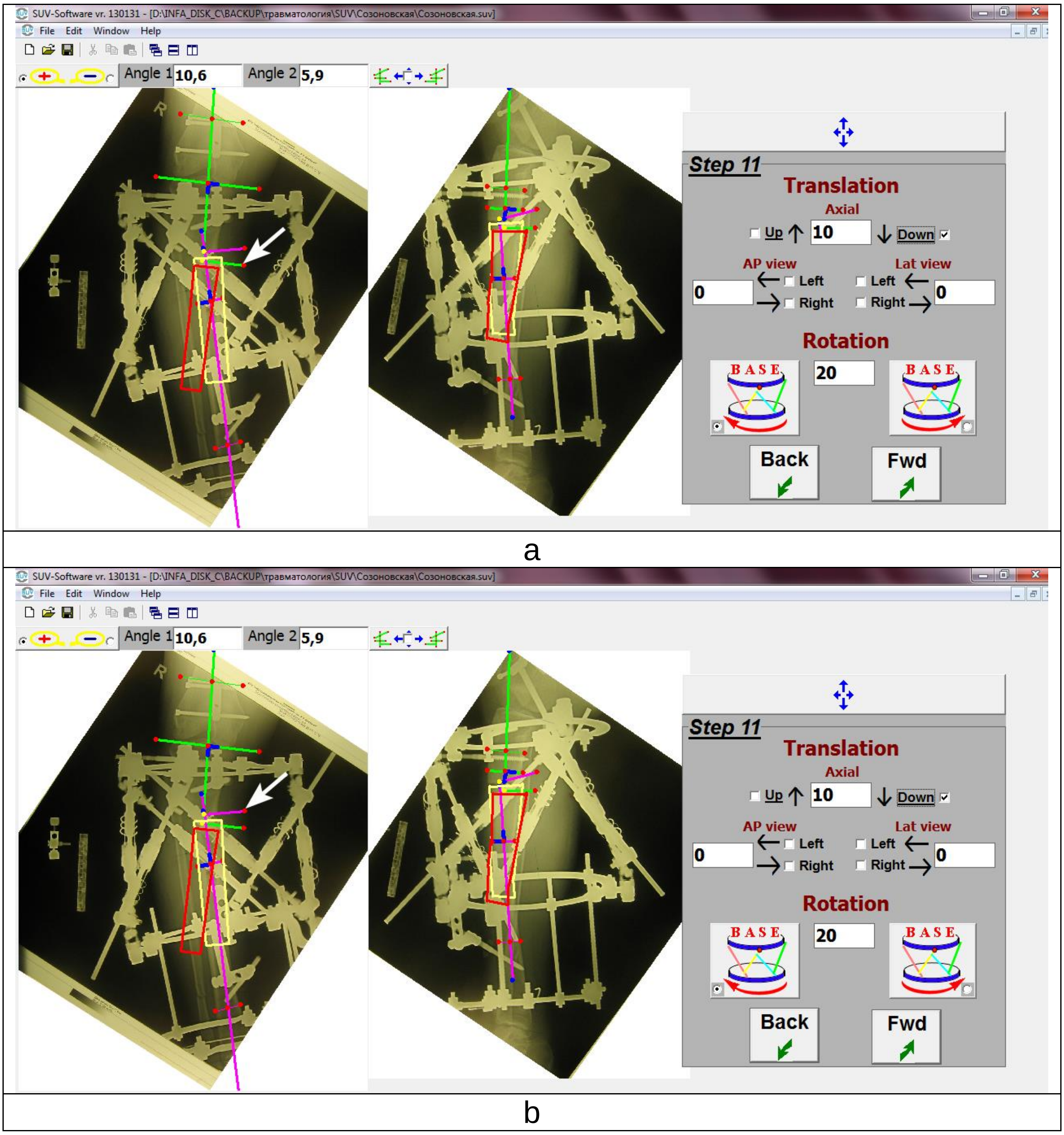


Fig. 72. Ortho-SUV program window in Step 11: performance of command “to confirm moving” (“click pointer”). **a -** after having placed cursor at red point connected with pointer of proximal fragment border (“yellow point”) (specified by arrow), left button of the mouse must be pressed. **b** – the same “click pointer” procedure must be done for mobile fragment (pointed by arrow)

NB!

Do not forget to execute the command “to confirm moving” (“click pointer”).

If you are convinced of correct position of the mobile bone fragment (i.e. red bone contour), press button "Fwd". If after pressing button “Fwd” an icon “Click the pointer” will appear, it is necessary to repeat procedure “to confirm moving” (Fig. 72), using pointers not only in lateral view, but also in AP view.

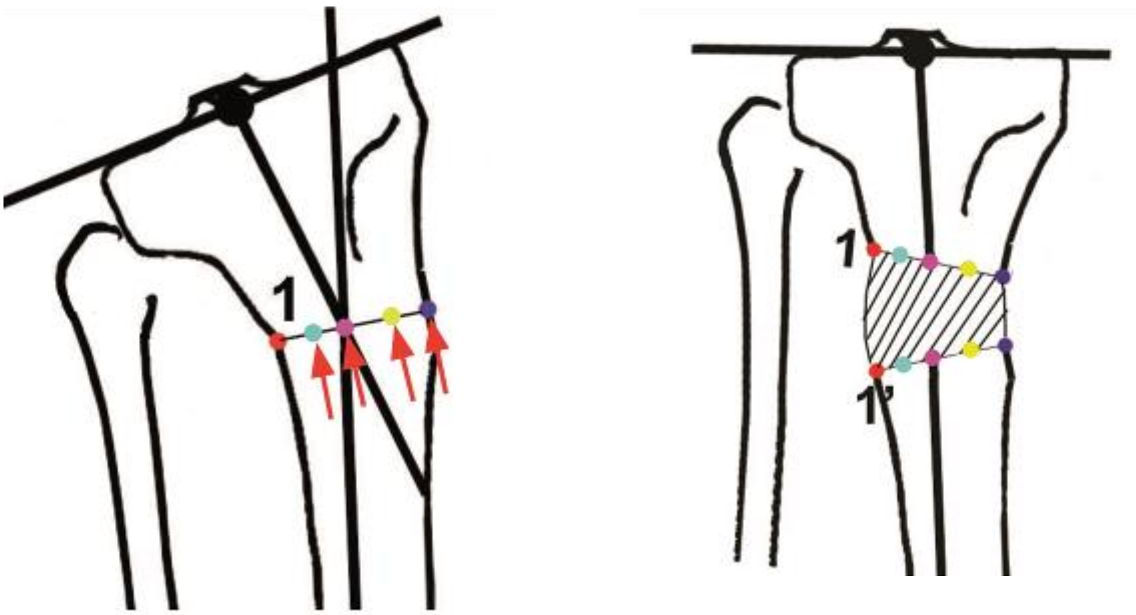
Step 12: Designation of “Structures at Risk”.

Performance of Step 12 allows the program to obtain the data for calculation of necessary *rate of deformity correction*. The parameters given are “Structures at Risk” (SAR).

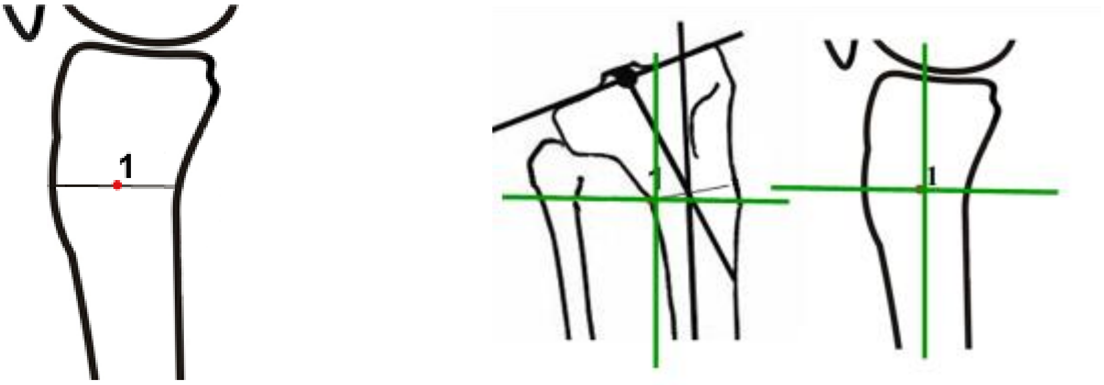
The first structure at risk (SAR #1) is a point located on proximal edge of mobile fragment which at deformity correction or reduction of fracture will be moved by the maximal distance. Localization of this point must be identified using basic knowledge of long bone deformity correction.

For example, there are valgus and shortening. In this case the point which is located at osteotomy level in a projection of external cortex after deformity correction will be moved at the greater distance, than any of the points which are closer to internal cortex. This point must be designated, as SAR #1 (Fig. 73). SAR #1 also must be marked in the lateral view. SAR #1 on the lateral view must be the same point, which was chosen for the AP view (Fig. 73c,d).

NB!
SAR must be the same points for AP and lateral view.



a b



c d

Fig. 73. Identification of SAR #1, i.e. point of mobile fragment which during deformity correction will pass the greatest distance. **a –** there are valgus and shortening. Osteotomy has been made at CORA level. Number of points are put on osteotomy line from internal up to external cortexes (specified by arrows). **b -** point 1 during deformity correction will be moved at distance (1-1'). This distance is more, than distance at which any of points, located closer to medial cortex, are being moved. Thus, the point "1" is SAR #1. **c** - projection of SAR #1 on the lateral view is shown. It must be the same point, which has been identified on AP! **d -** SAR #1 is marked by tool "green cross" on AP and lateral view

The second structure at risk (SAR #2) is a point in a projection of main vessels and nerves, which during deformity correction or reduction of fracture will be maximally stretched. Localization of this point must be identified using basic knowledge of topographic anatomy and long bone deformity correction.

For example, there are valgus and shortening of proximal tibia. In this case peroneal nerve will be most stretched during deformity correction. Therefore the projection of peroneal nerve is SAR #2 (Fig. 74). SAR #2 should be marked on the lateral view too. It must be the same point, which has been determined for AP view.

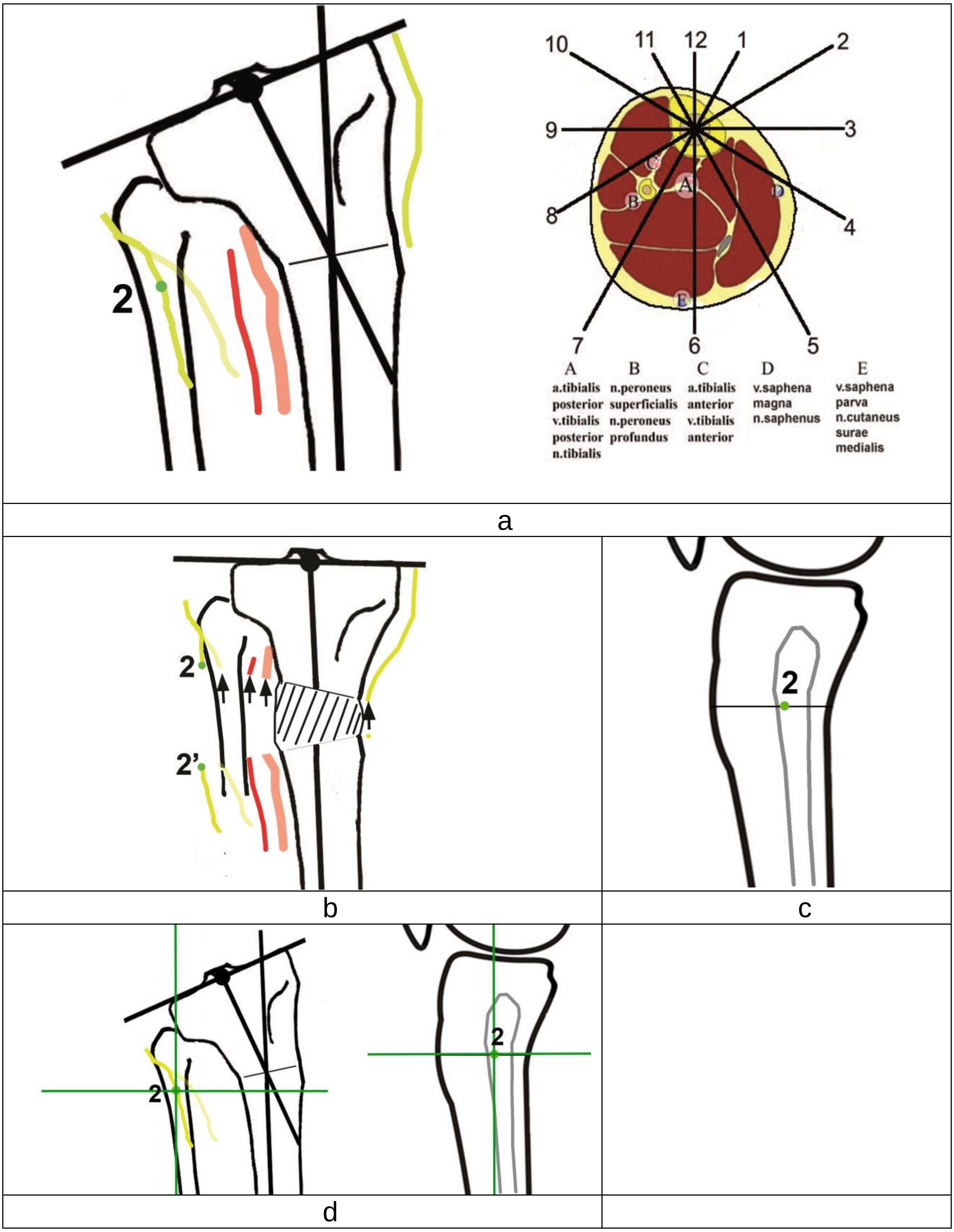


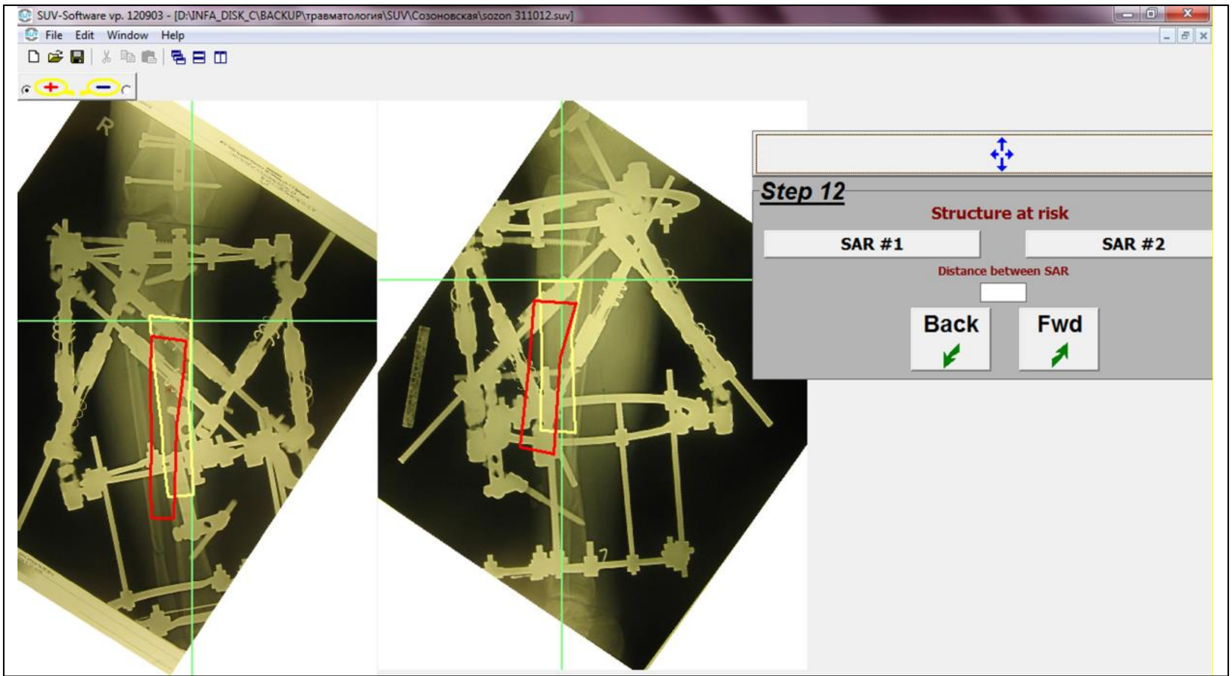
Fig. 74. Identification of SAR #2, i.e. point in projection of main vessels and nerves, which during deformity correction or reduction of fracture will be maximally stretched. **a –** there are valgus and shortening. **b** - during deformity correction peroneal nerve will be stretched much more, than other vessels and nerves of lower leg. Thus, projection of peroneal nerve is SAR #2. **c** - projection of SAR #2 on the lateral view is shown. It must be the same point, which has been identified on AP! **d -** SAR #2 is marked by the tool “green cross” on AP and lateral view

There is a special tool for SAR designation: two intercrossing lines of green color - “green cross”. Place the cursor at the centre of the green cross on AP view. Than press the left button of the mouse and move the green cross to the projection of SAR #1. The same way SAR #1 must be marked on the lateral view. After that press the button “SAR #1”.

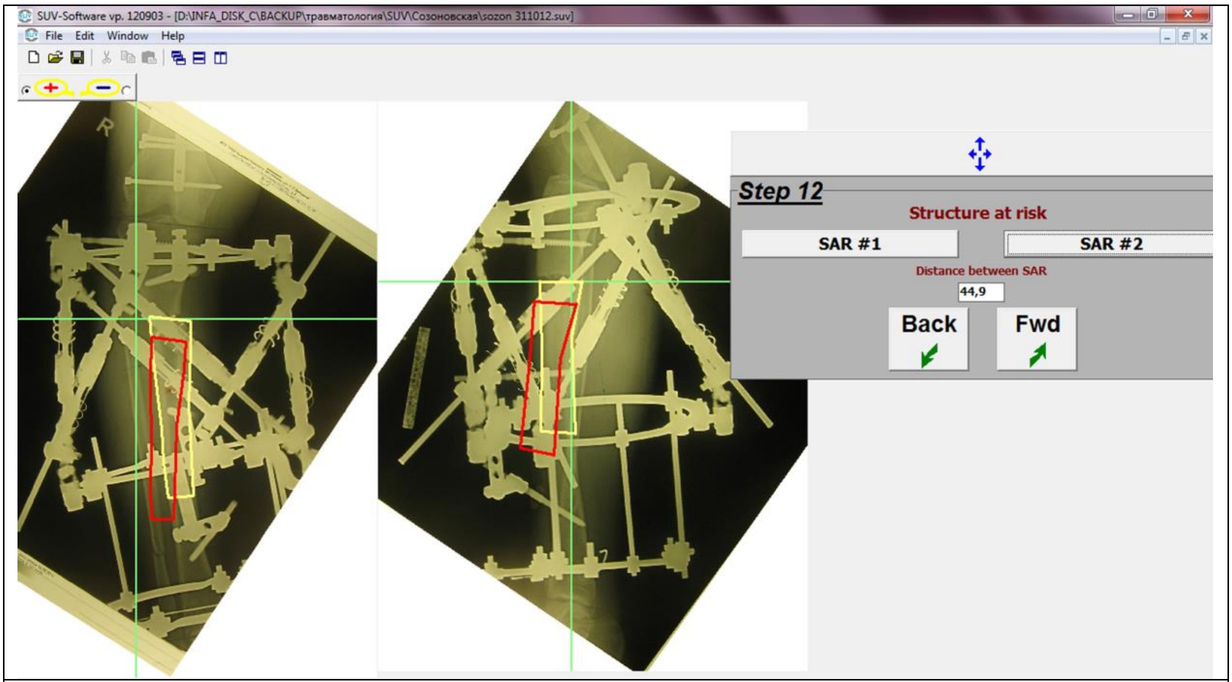
Next step is marking of SAR #2. To do this move the green cross in projection of SAR #2 sequentially on AP and Lat view. Finally press the button “SAR #2”. After that in the window “Distance between SAR” distance between SAR in mm can be seen (Fig. 75).

When the orthopedic surgeon is convinced, that the stretching of main vessels and nerves can be ignored, SAR #2 should not be designated. For example, at segment lengthening the stretching of vessels, nerves and length of regenerate will be equal. The other example is femur valgus deformity correction, because the length of regenerate will exceed a stretching of vessels and nerves. In similar cases after designation of SAR #1, the button SAR #2 must immediately be pressed. After that in the window “Distance between SAR” digit "0" will appear. For the program it means that SAR #1 and SAR #2 coincide.

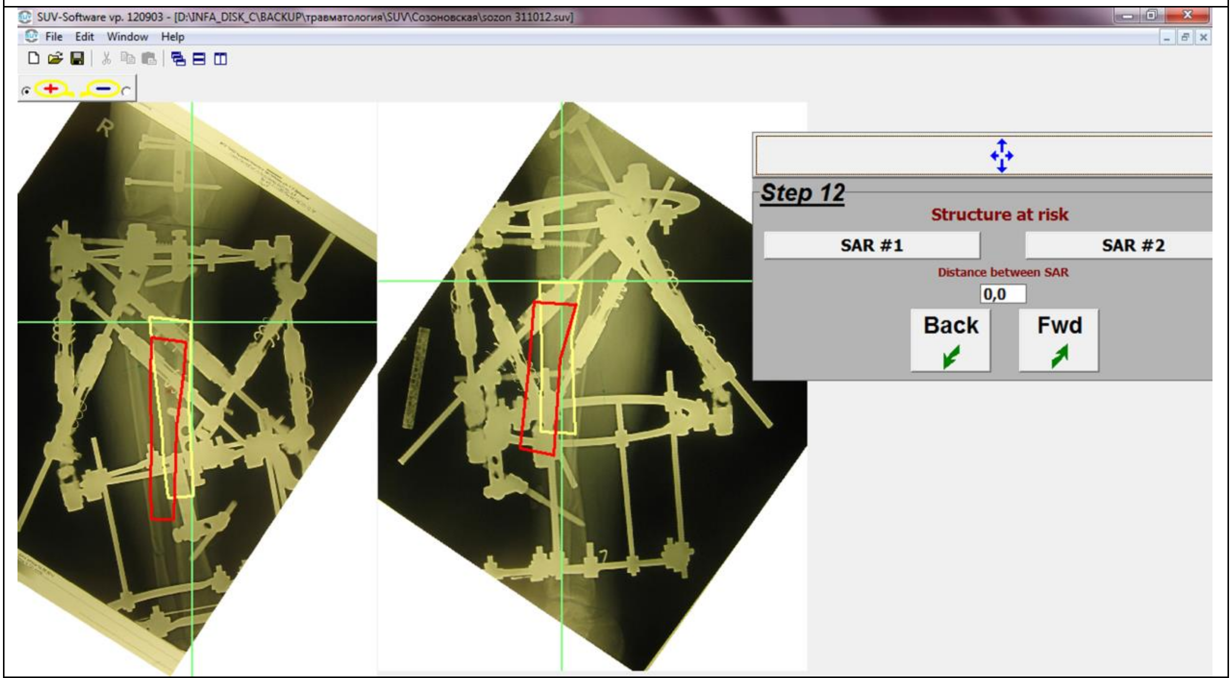
After SAR designation button "Fwd" must be pressed.



a



b



c

Fig. 75. Ortho-SUV program window in Step 12: identification of structures at risk - SAR. **a -** SAR #1 on AP and Lat view is marked by the tool “green cross”. It must be the same point! After that button “SAR #1” is being pressed. **b -** SAR #2 on AP and Lat view is marked by the tool “green cross”. It must be the same point! After that button “SAR #2” is being pressed. In window “Distance between SAR” figure 44.9 has appeared. It is distance between SAR in mm. **c** – it was decided to ignore SAR #2. For this purpose after designation of SAR #1 button SAR #2 should immediately be pressed. After that in the window “Distance between SAR” digit "0" has appeared. For the program it means SAR #1 and SAR #2 coincide.

Step 13: Strut Length Change

To define the rate of deformity correction (fracture reduction) a value (in mm/day) is entered in the “Rate of correction” field (Fig. 76). The default value is 1 mm/day but the user can enter any other value; the minimal value is 0.1 mm/day.

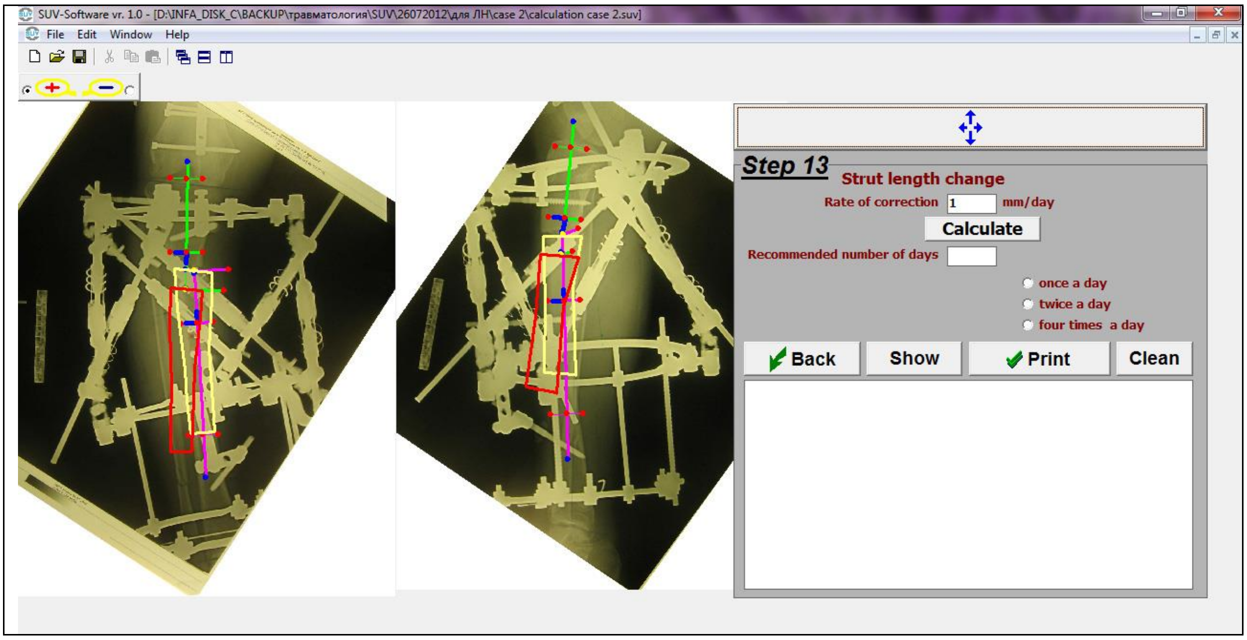


Fig. 76. Ortho-SUV program window in Step 13: choice of rate of correction. The deformity correction rate has been entered: 1 mm/day

Next, click the “Calculate” button; the program will calculate the number of days required for the deformity correction at the given rate. Result of calculation appears in a field “Recommended number of days” (Fig. 77). Calculated by software number of days provides daily moving any of SAR not more, than by value chosen, for example, 1 mm/day.

Note, that the user has a possibility to ignore the number of days calculated by the program. Just remove it and enter the number of days required.

There is another possibility to change number of days for deformity correction. For this purpose it is necessary to change value in the field “Rate of correction”, for example, 2.5 mm/day, and again (do not forget it!) to press the button "Calculate".

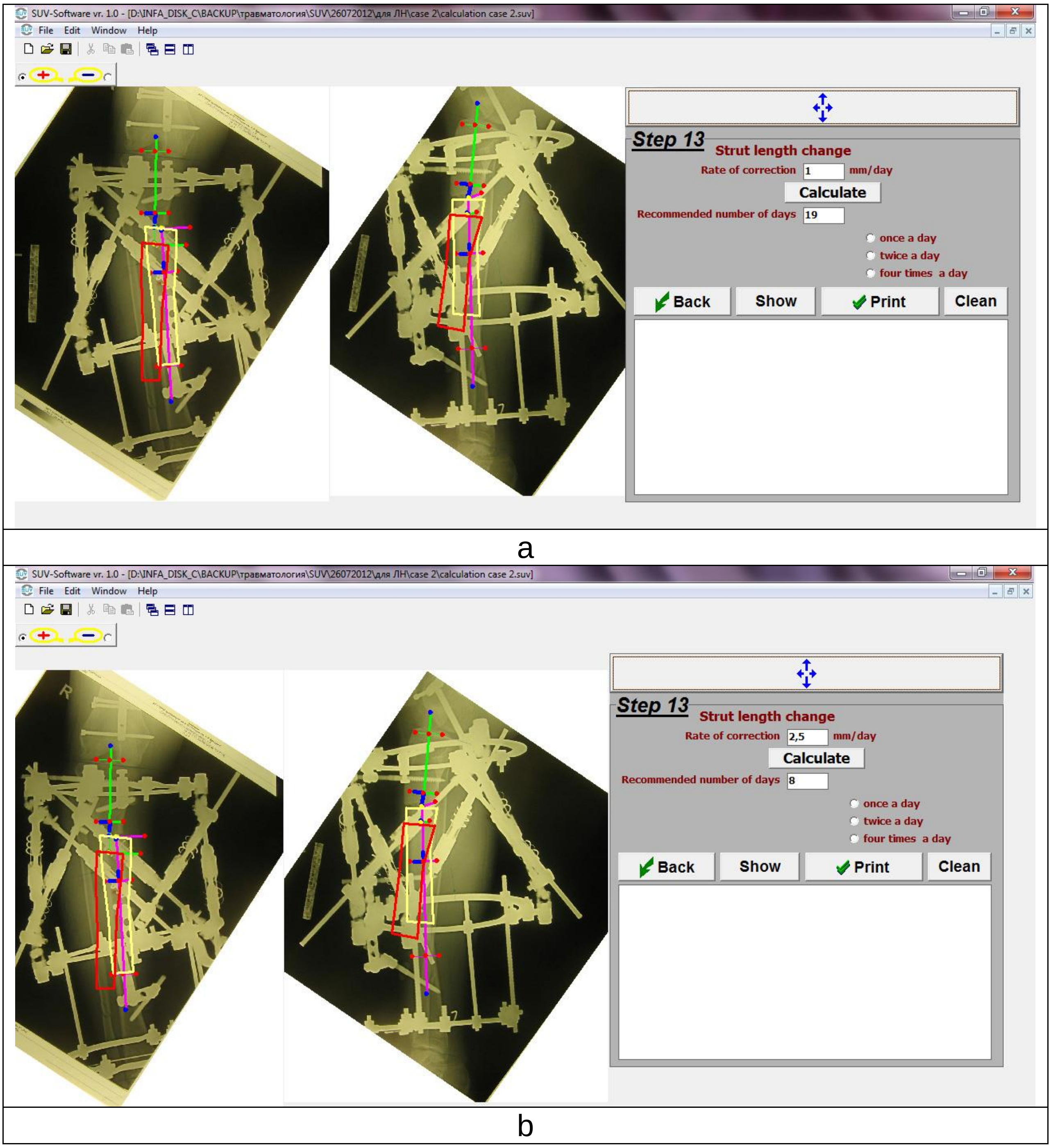
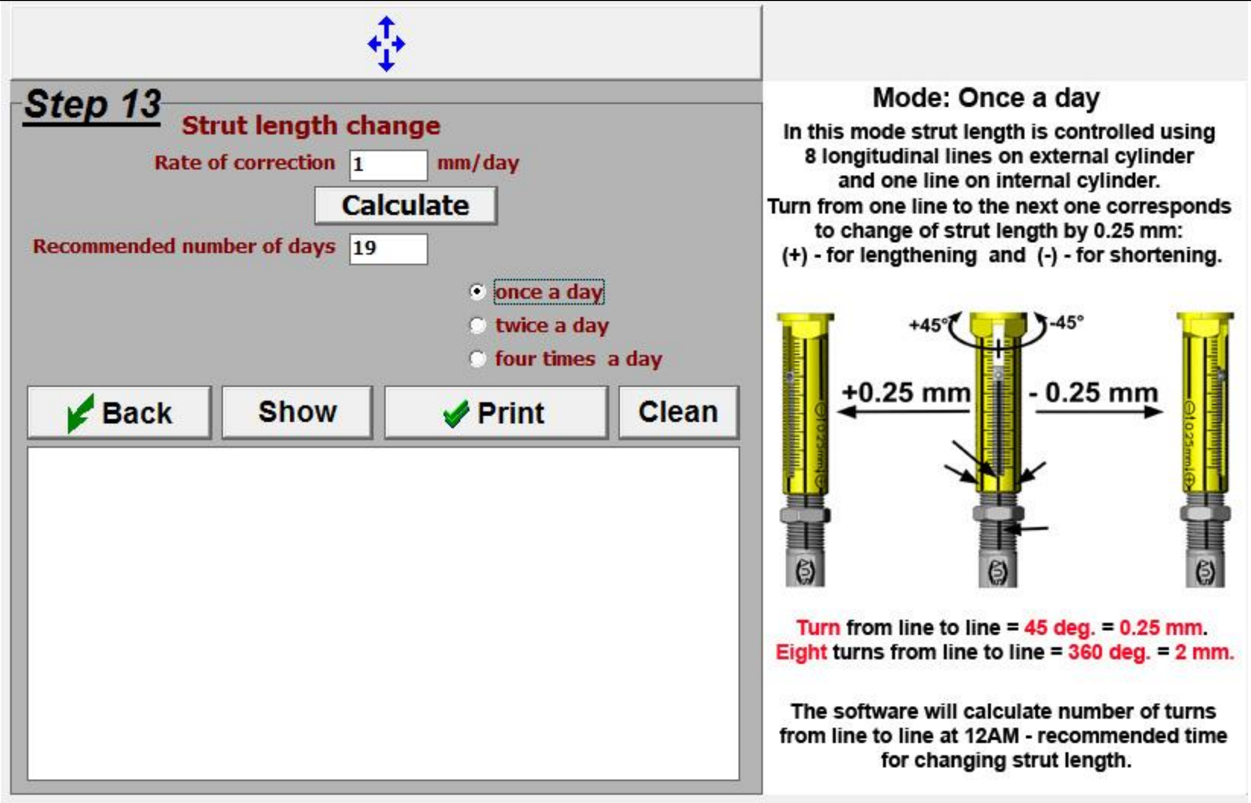
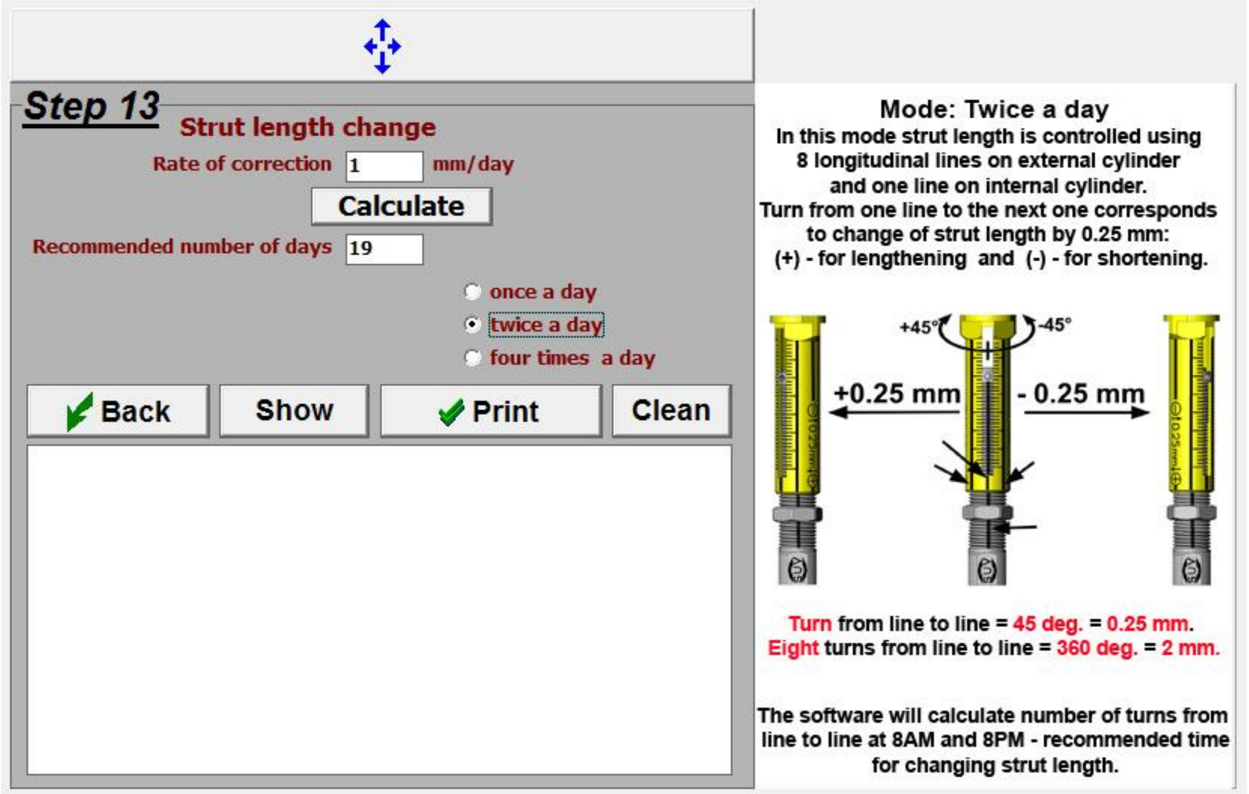


Fig. 77. Ortho-SUV program window in Step 13: identification numbers of days needed for deformity correction. **a -** software has calculated recommended number of days for deformity correction at rate 1 mm/day - 19 days. The user can ignore this value. To do this just remove it and enter number of days required. **b** - there is another possibility to change number of days for deformity correction. For this purpose it is necessary to change value in the field “Rate of correction” for necessary one (for example, 2.5 mm/day) and again (do not forget it!) press the button "Calculate". The program has calculated, that at new rate 8 days are necessary for deformity correction

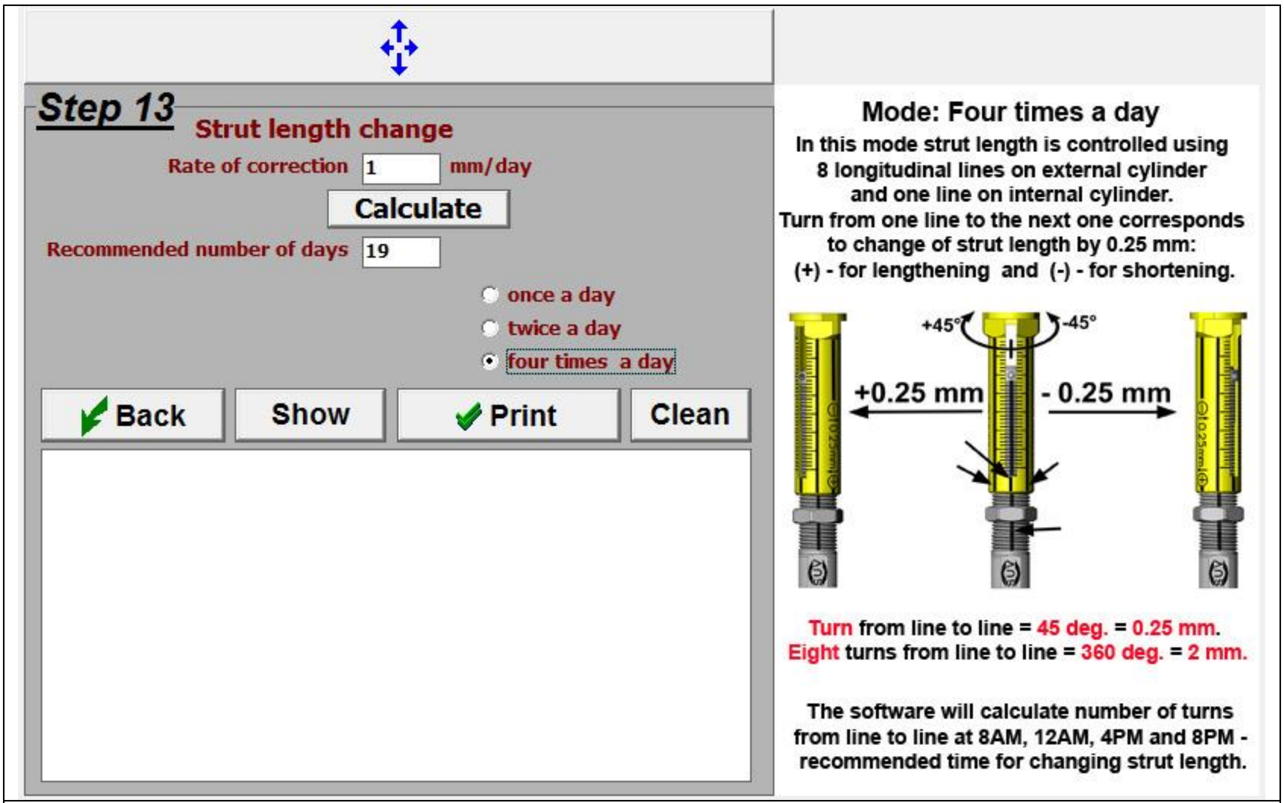
After that the user should specify at what rate lengths of strut can be changed. The program gives a choice: once a day, twice a day and four times a day. Having made a choice tick in an appropriate window: “Once a day", " Twice a day" and "Four times a day". Right after tick has been put, the help will appear to the right of the basic window (Fig. 78).



a



b



c

Fig. 78. Ortho-SUV program window in Step 13: choice of number of strut change lengths a day. Possible variants of choice and the helps given by the program are shown

After that number of days and rate of correction have been identified, the button “Show” must be pressed. After calculations the program will show the table of values of daily change of strut lengths (Fig. 79). The first column of the table shows number of days of deformity correction. Six next columns show lengths each of struts. Rows of days are divided by rows of time recommended for changing strut lengths.

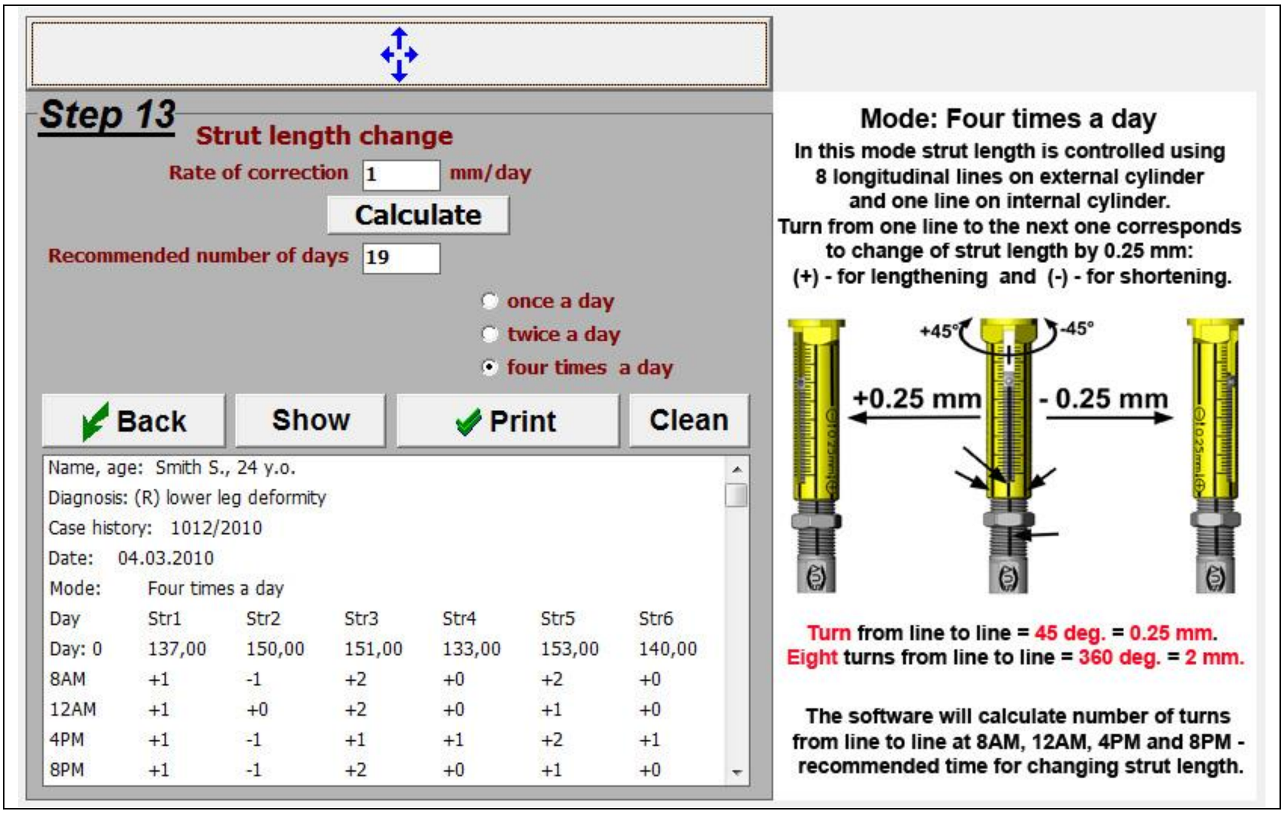


Fig. 79. Ortho-SUV program window in Step 13: table of deformity correction protocol

The table, using button "Print", should be printed out and used in daily control for deformity correction. The printed table contains the help (Fig. 80).

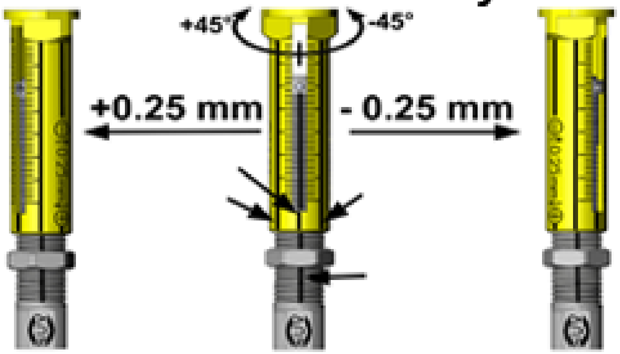
Name, age: Smith, 24 y.o.

Diagnosis: (R) Lower leg deformity

Case history: 2412

Date: 04/03/2010

Mode: *Once a day*



Note! **In this mode strut length is controlled using 8 longitudinal lines on external cylinder and one line on internal cylinder. Turn from one line to the next one corresponds to change of strut length by 0.25 mm: (+) - for lengthening and (-) - for shortening.**

Turn from line to line = 45 deg. = 0.25 mm. Eight turns from line to line = 360 deg. = 2 mm.

The software calculates number of turns from line to line at 12AM - recommended time for changing strut length. For example, "+2" means "two lines (i.e. 0.5 mm) for strut lengthening".

Mode: Once a day

Day	Str1	Str2	Str3	Str4	Str5	Str6
Day: 0	137,00	150,00	151,00	133,00	153,00	140,00
12AM	+8	-3	+19	+4	+14	-4
Day: 1	139,00	149,25	155,75	134,00	156,50	139,00
12AM	+8	-3	+19	+4	+14	-5
Day: 2	141,00	148,50	160,50	135,00	160,00	137,75
12AM	+9	-3	+19	+4	+13	-4
Day: 3	143,25	147,75	165,25	136,00	163,25	136,75
12AM	+8	-3	+18	+4	+14	-5
Day: 4	145,25	147,00	169,75	137,00	166,75	135,50
12AM	+8	-3	+19	+3	+14	-4
Day: 5	147,25	146,25	174,50	137,75	170,25	134,50
12AM	+8	-4	+19	+4	+14	-4
Day: 6	149,25	145,25	179,25	138,75	173,75	133,50
12AM	+8	-3	+19	+4	+14	-5
Day: 7	151,25	144,50	184,00	139,75	177,25	132,25
12AM	+9	-3	+19	+4	+13	-4
Day: 8	153,50	143,75	188,75	140,75	180,50	131,25

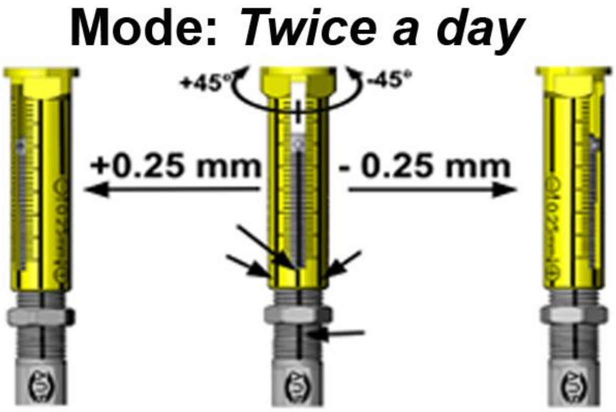
a

Name, age: Smith, 24 y.o.

Diagnosis: (R) Lower leg deformity

Case history: 2412

Date: 04/03/2010



Note! **In this mode strut length is controlled using 8 longitudinal lines on external cylinder and one line on internal cylinder. Turn from one line to the next one corresponds to change of strut length by 0.25 mm: (+) - for lengthening and (-) - for shortening.**

Turn from line to line = 45 deg. = 0.25 mm. Eight turns from line to line = 360 deg. = 2 mm.

The software calculates number of turns from line to line at 8AM and 8PM - recommended time for changing strut length. For example, "+2" means "two lines (i.e. 0.5 mm) for strut lengthening".

Mode: Twice a day

Day	Str1	Str2	Str3	Str4	Str5	Str6
Day: 0	137,00	150,00	151,00	133,00	153,00	140,00
8AM	+4	-2	+9	+2	+7	-2
8PM	+4	-1	+10	+2	+7	-2
Day: 1	139,00	149,25	155,75	134,00	156,50	139,00
8AM	+4	-2	+9	+2	+7	-3
8PM	+4	-1	+10	+2	+7	-2
Day: 2	141,00	148,50	160,50	135,00	160,00	137,75
8AM	+5	-2	+9	+2	+6	-2
8PM	+4	-1	+10	+2	+7	-2
Day: 3	143,25	147,75	165,25	136,00	163,25	136,75
8AM	+4	-2	+9	+2	+7	-2
8PM	+4	-1	+9	+2	+7	-3
Day: 4	145,25	147,00	169,75	137,00	166,75	135,50
8AM	+4	-2	+10	+2	+7	-2
8PM	+4	-1	+9	+1	+7	-2
Day: 5	147,25	146,25	174,50	137,75	170,25	134,50
8AM	+4	-2	+10	+2	+7	-2
8PM	+4	-2	+9	+2	+7	-2
Day: 6	149,25	145,25	179,25	138,75	173,75	133,50
8AM	+4	-1	+10	+2	+7	-2
8PM	+4	-2	+9	+2	+7	-3
Day: 7	151,25	144,50	184,00	139,75	177,25	132,25

b

Name, age: Smith, 24 y.o.

Diagnosis: (R) Lower leg deformity

Case history: 2412

Date: 04/03/2010

Mode: *Four times a day*

Note!
In this mode strut length is controlled using 8 longitudinal lines on external cylinder and one line on internal cylinder. Turn from one line to the next one corresponds to change of strut length by 0.25 mm: (+) - for lengthening and (-) - for shortening.

Turn from line to line = 45 deg. = 0.25 mm. Eight turns from line to line = 360 deg. = 2 mm.

The software calculates number of turns from line to line at 8AM, 12AM, 4PM and 8PM - recommended time for changing strut length. For example, "+2" means "two lines (i.e. 0.5 mm) for strut lengthening".

Mode: Four times a day

Day	Str1	Str2	Str3	Str4	Str5	Str6
Day: 0	137,00	150,00	151,00	133,00	153,00	140,00
8AM	+2	-1	+5	+1	+3	-1
12AM	+2	-1	+4	+1	+4	-1
4PM	+2	+0	+5	+1	+3	-1
8PM	+2	-1	+5	+1	+4	-1
Day: 1	139,00	149,25	155,75	134,00	156,50	139,00
8AM	+2	-1	+5	+1	+3	-1
12AM	+2	-1	+4	+1	+4	-2
4PM	+2	+0	+5	+1	+3	-1
8PM	+2	-1	+5	+1	+4	-1
Day: 2	141,00	148,50	160,50	135,00	160,00	137,75
8AM	+2	-1	+4	+1	+3	-1
12AM	+3	-1	+5	+1	+3	-1
4PM	+2	-1	+5	+1	+4	-1
8PM	+2	+0	+5	+1	+3	-1
Day: 3	143,25	147,75	165,25	136,00	163,25	136,75
8AM	+2	-1	+4	+1	+4	-1
12AM	+2	-1	+5	+1	+3	-1
4PM	+2	-1	+5	+1	+4	-1
8PM	+2	+0	+4	+1	+3	-2
Day: 4	145,25	147,00	169,75	137,00	166,75	135,50

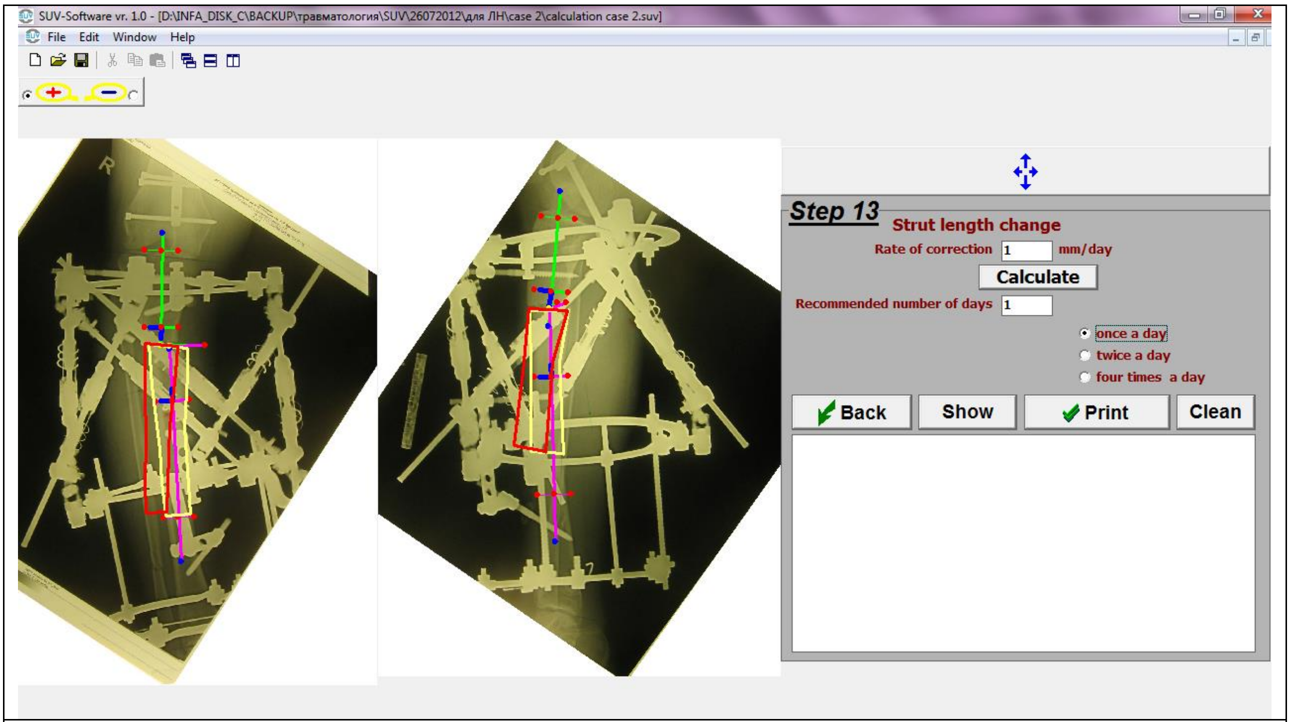
c

Fig. 80. Printed table of deformity correction protocol. **a-c** - examples of tables calculated for different rates of strut lengths change

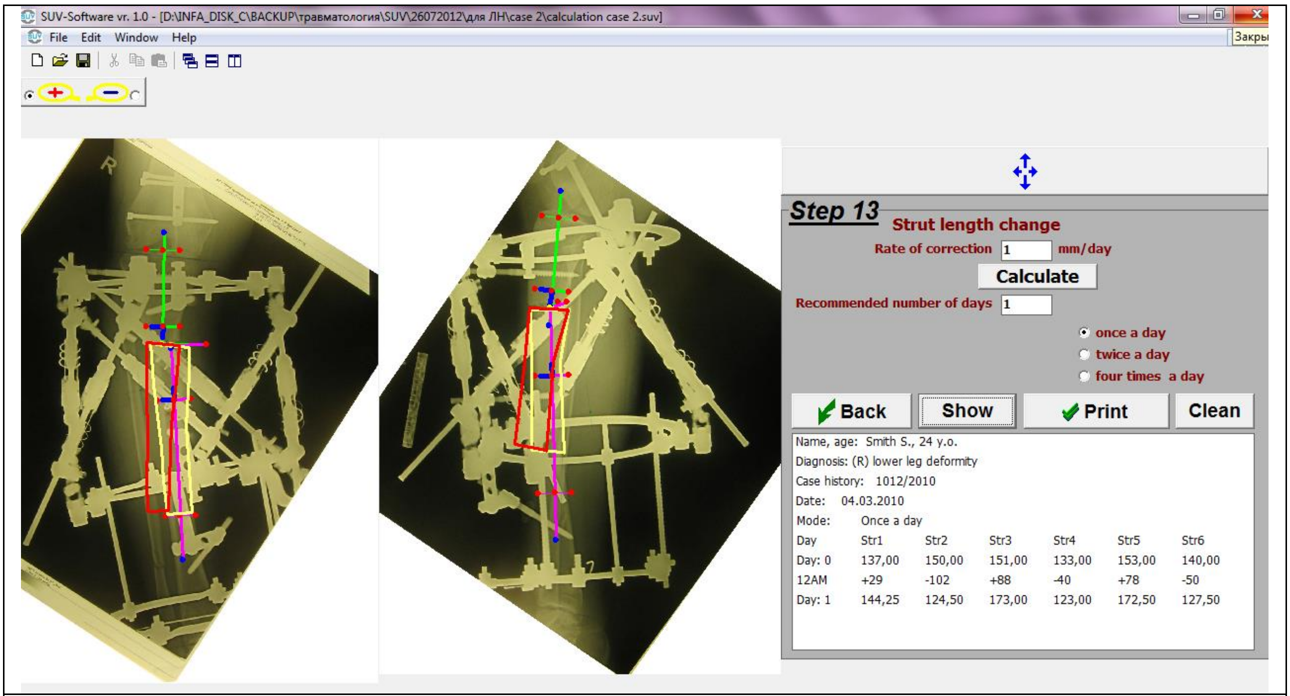
At end of work with the program (as well as after each Step) the file must be saved using the standard button of the panel of tools. It is always possible to return to this file for control and recalculation. The file opens from the Step at which the program was closed.

NB!

At acute deformity correction sizes of those struts to be extended must be firstly changed. Only after that the struts recommended by software should be shortened (Fig. 81). It allows avoiding possible "interengage" of bone fragments.



a



b

Fig. 81. Ortho-SUV program window in Step 13 at acute deformity correction. **a** - number "1" is entered into window “Recommended number of days”. **b –** there are three rows in table: initial strut length (row “Day: 0”), final strut length (row “Day: 1”) and between them row "12AM" – number of clicks needed for change of strut length. First length of struts ## 1, 3 and 5 should be changed, because they are lengthened. Only after that it is necessary to shorten struts ## 2, 4 and 6.

NB!

*If for some reason difficulties have occurred (usually associated with incorrect usage), save the file, archive the case folder (AP, Lat view, and "**.suv"-file) and send it to the following email address: orthosuv@gmail.com . In the accompanying message, explain in detail the problem that has been encountered. To resume working, it is usually enough to re-start the program and, obviously, avoid one’s previous mistakes.*

6. Application of Ortho-SUV Frame: Clinical Cases

6.1 Application of Ortho-SUV Frame in fracture treatment

22 y.o. patient B. was hospitalized with the diagnose: malunited midshaft fracture of the left tibia with shortening, translation, and angulation of bone fragments (Fig. 82a).

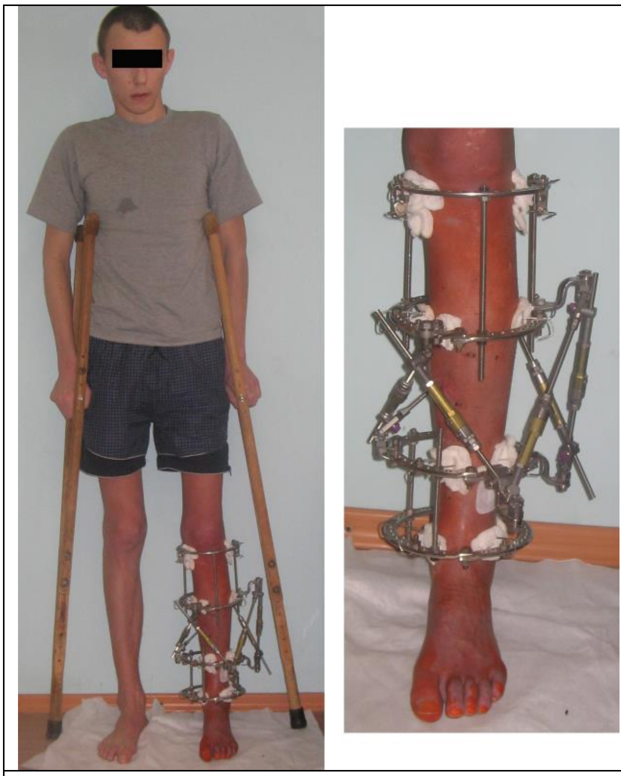
External fixation of left lower leg using an Ortho-SUV Frame has been performed. Wires were inserted in a way, that not to interfere with consequent nailing (Fig. 82b):

Method of the Unified Designation of External Fixation (MUDEF):

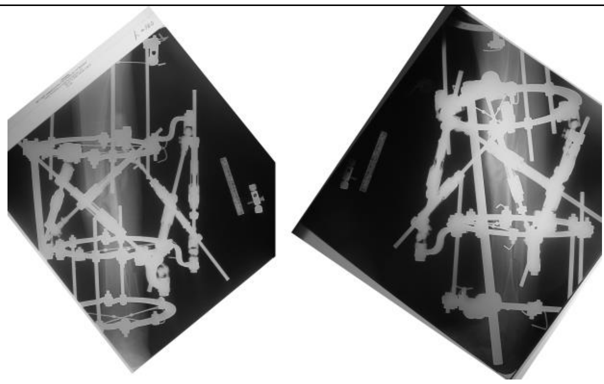
$$\frac{\mathrm{I},\mathbf{9}\text{-}3;\ \mathrm{II},\mathbf{9}\text{-}3}{2/3\ 140} - \frac{\mathrm{IV},\mathbf{3}\text{-}9}{140} - \text{Ortho-SUV} - \frac{\mathrm{IV},\mathbf{3}\text{-}9}{140} - \frac{\mathrm{IX}\ (\mathbf{8}\text{-}2)\mathrm{IX},8\text{-}2;\ \mathrm{IX},\mathbf{4}\text{-}10}{140}$$

An attempt of close reduction in «fast struts» provided an improvement of bone fragment position (Fig. 82c). Ortho-SUV software was used to calculate elimination of residual displacement (Fig. 82d). Bone fragment reduction carried out within 10 days (Fig. 82e). After that nailing was executed (Fig. 82f,g).

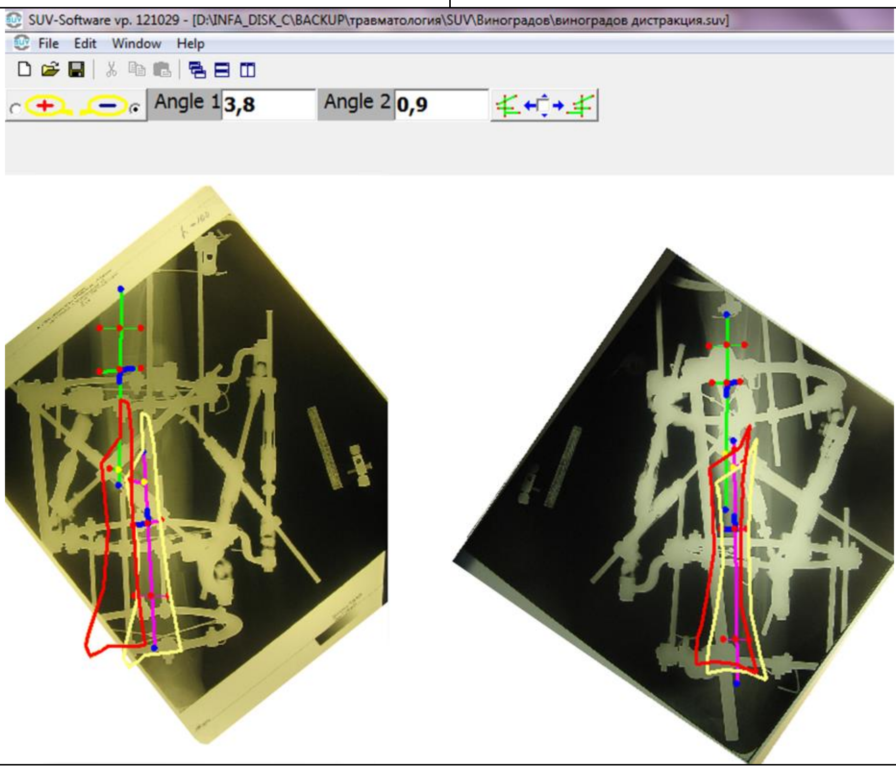
a



b



c


SUV-Software vp. 121029 - [D:\INFA_DISK_C\BACKUP\травматология\SUV\Виноградов\виноградов дистракция.suv]
File Edit Window Help
Angle 1 3,8
Angle 2 0,9

d

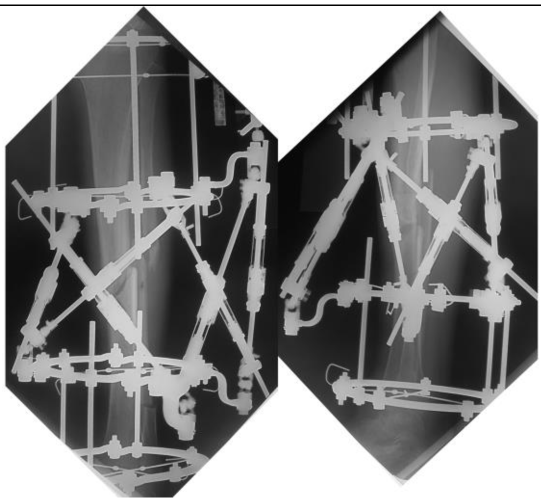
	
e	f
	
g	

Fig. 82. Photographs and roentgenograms of patient B.

6.2 Application of Ortho-SUV Frame in diaphyseal deformities.

6.2.1 Both lower legs non-unions accompanied with complex deformities

45 y.o. patient E., was hospitalized with the diagnose: nonunions of distal third in both tibias. Complex six-component, three-planar deformity of right lower leg. Complex five-component, two-planar deformity of left lower leg (Fig. 83a).

At the first stage, combined external fixation of bones in both lower legs was performed using Ortho-SUV Frame (Fig. 83b).

For the right leg:

III,12,100; IV,**10**-4; V,2,80 _ Ortho-SUV _ VI,12,90; VII(**8**-2)8-2; VIII,1,90
150 150

For the left leg:

IV,12,100; V,**10**-4; VI,2,80 _ Ortho-SUV _ VII,12,90; VIII(**8**-2)8-2; VIII,**4**-10
150 150

The computer program was sequentially used for the right and left lower legs. Fragment markers were set over projections of anatomical axes of the bone fragments (Fig. 83c).

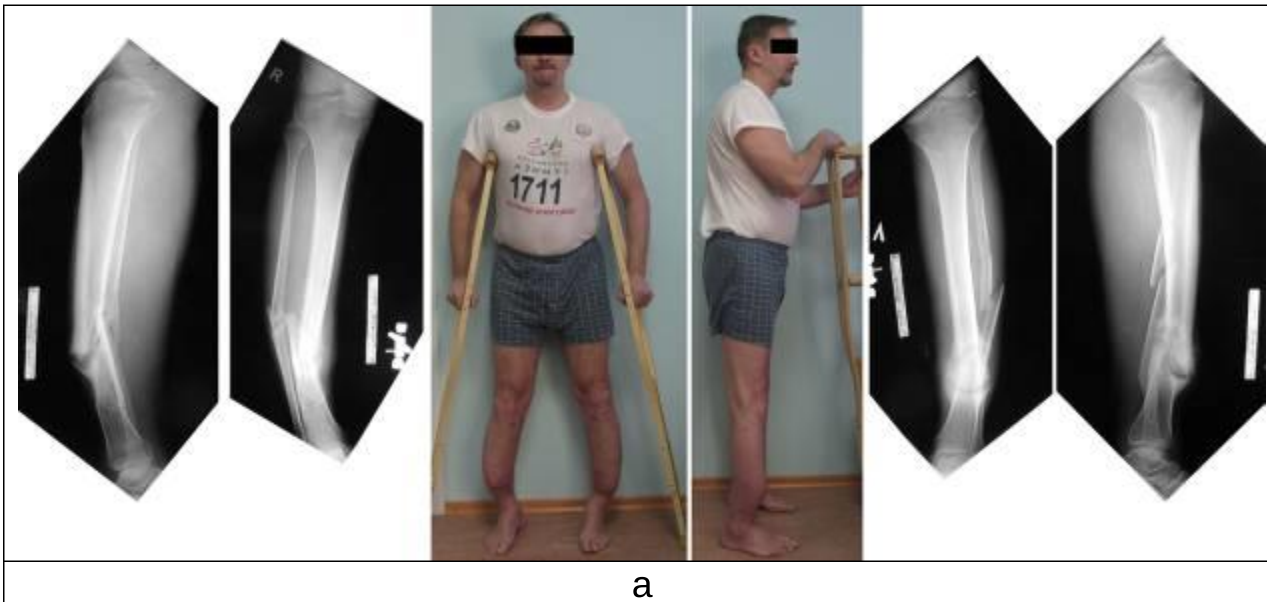
The rate of deformity correction was found by software in Step 12 according to SAR points. SAR #1 was set along the nonunion line, in the place where the mobile fragment in the process of its transport will cover the *longest distance* (Fig. 83d). SAR #2 was set in projection of main vessels and nerves (Fig. 83e).

In Step 12 the rate of deformity correction - 1 mm per day – was entered. After “Calculate” button was pressed, program calculated the recommended number of days required for correction of the deformity. When button «Show» had been pressed, in the lower right field of the display a table appeared displaying the values of daily length change for each strut (Fig. 83f). This table was printed out and given to the patient.

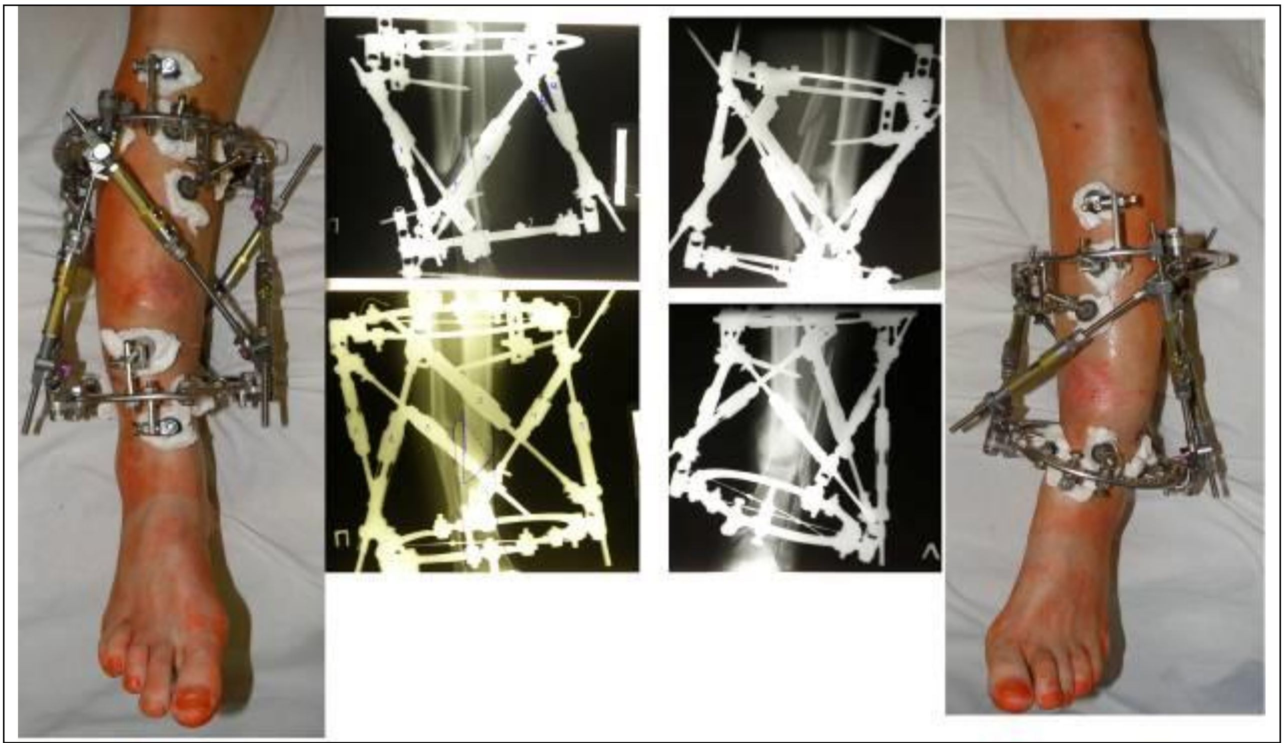
Calculation for deformity correction of the left lower leg was executed in the same way.

Deformity correction was performed according to the calculations made (Fig. 83g). Second stage involved nailing of both lower legs (Fig. 83h).

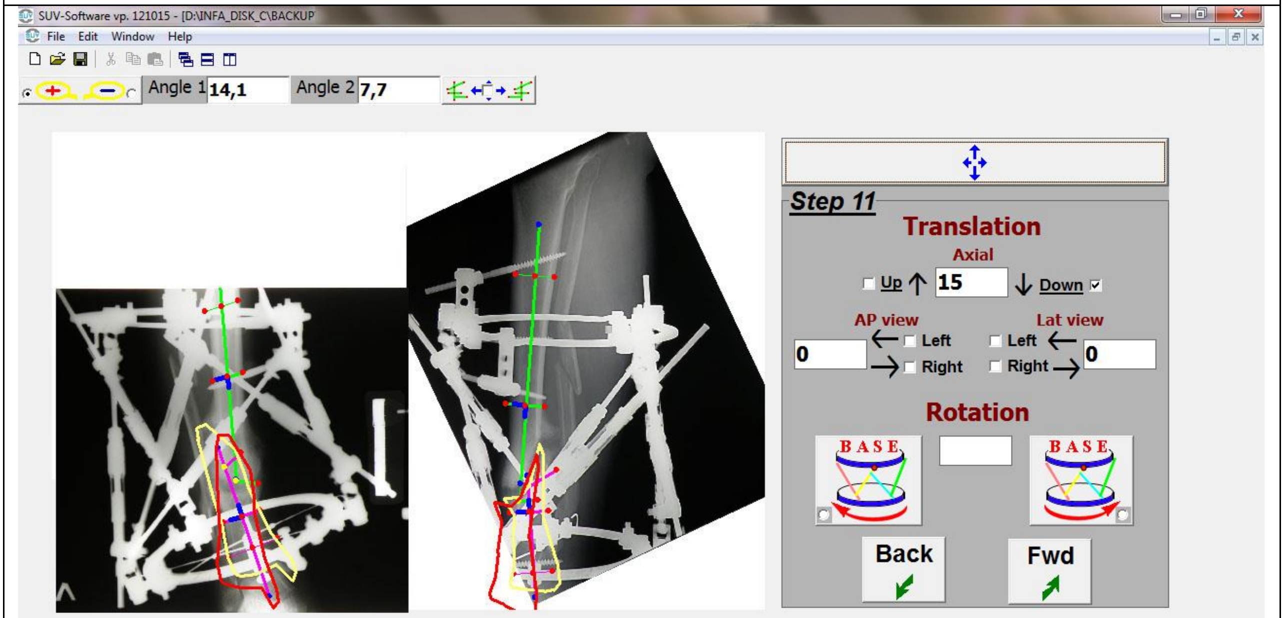
In 1.5 year after the surgery the locking nails were removed (Fig. 83i).



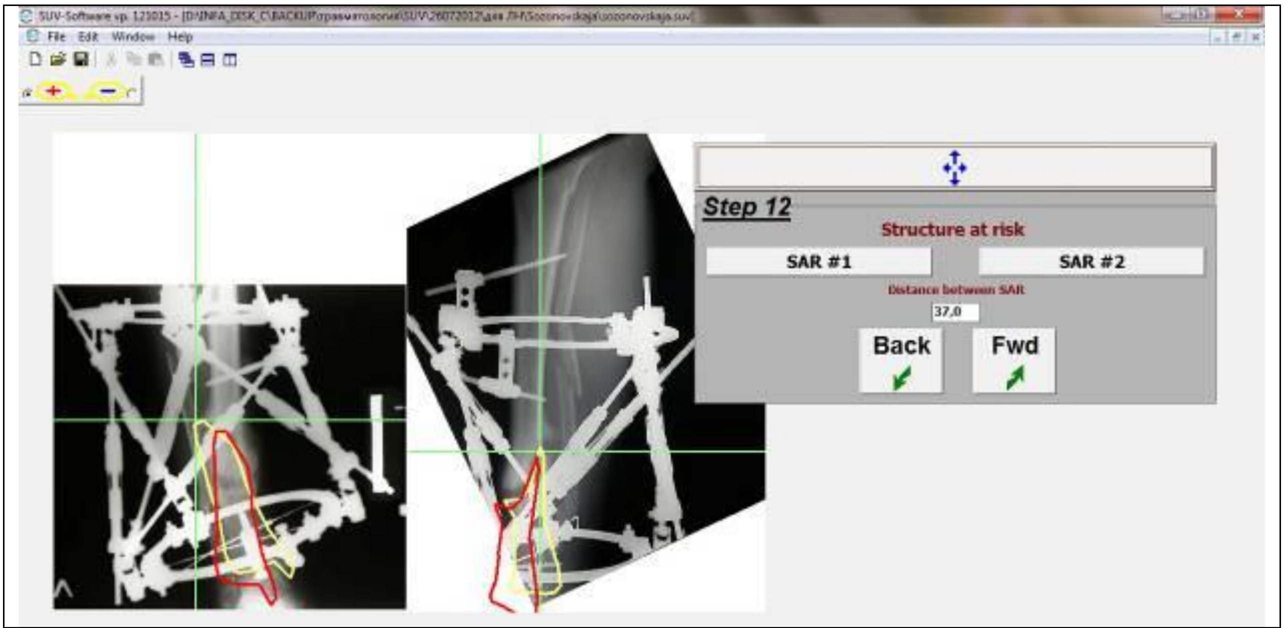
a



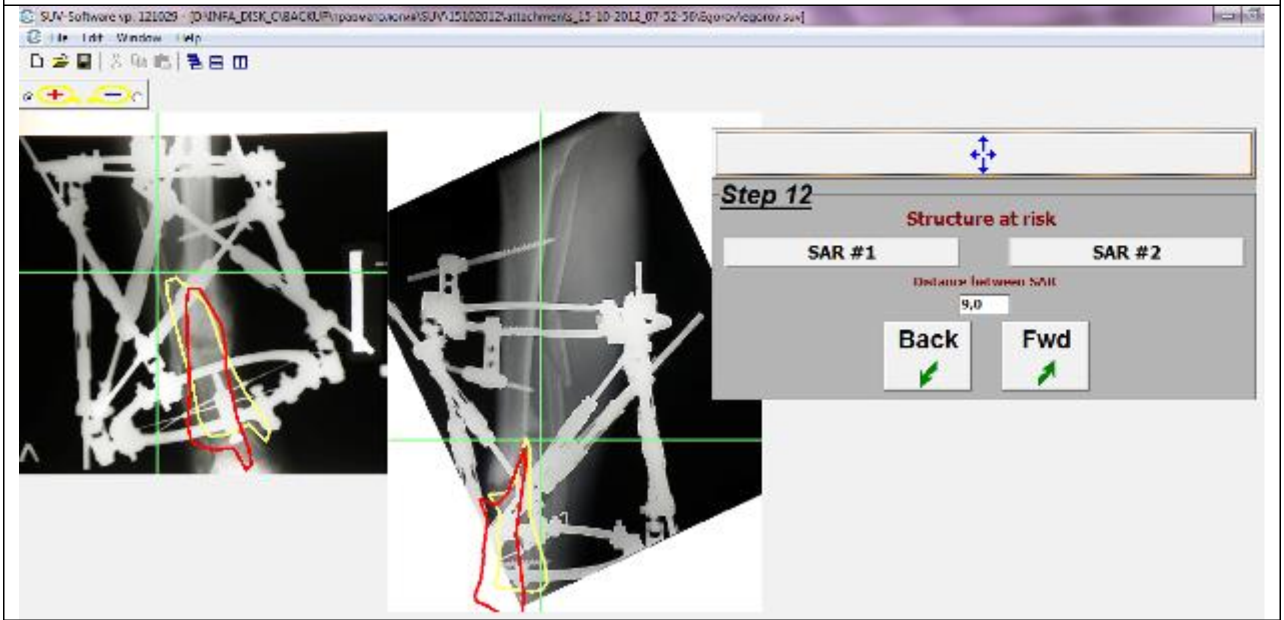
b


SUV-Software vp. 121015 - [D:\INFA_DISK_C\BACKUP
File Edit Window Help
Angle 1 14,1
Angle 2 7,7
Step 11
Translation
Axial
Up
15
Down
AP view
Left
Right
0
Lat view
Left
Right
0
Rotation
BASE
BASE
Back
Fwd

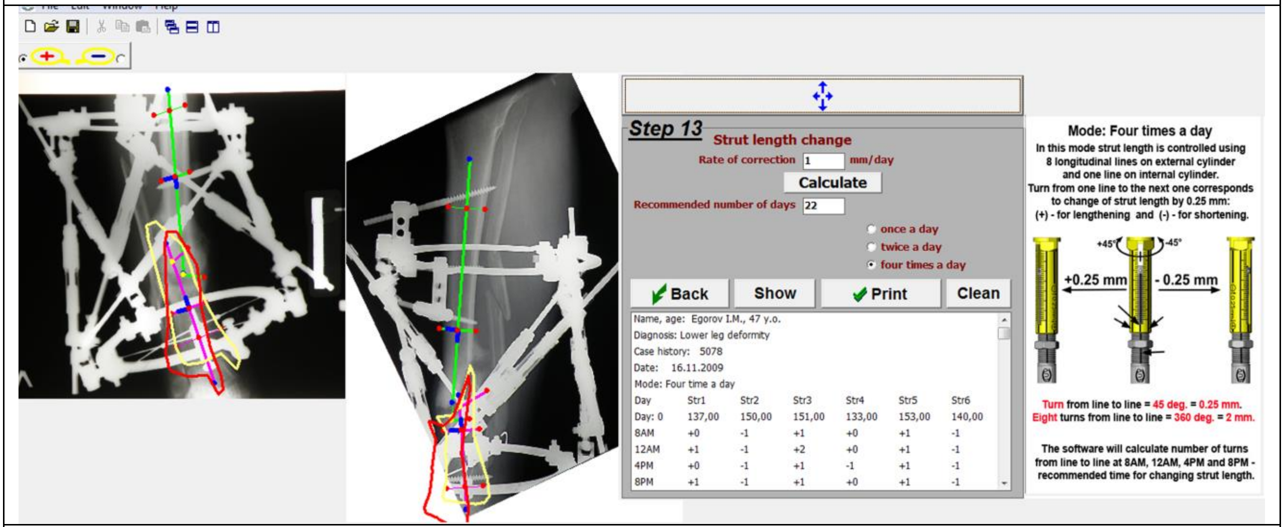
c


File Edit Window Help
Step 12
Structure at risk
SAR #1
SAR #2
Distance between SAR
37,0
Back
Fwd

d


Step 12
Structure at risk
SAR #1
SAR #2
Distance between SAR
9,0
Back
Fwd

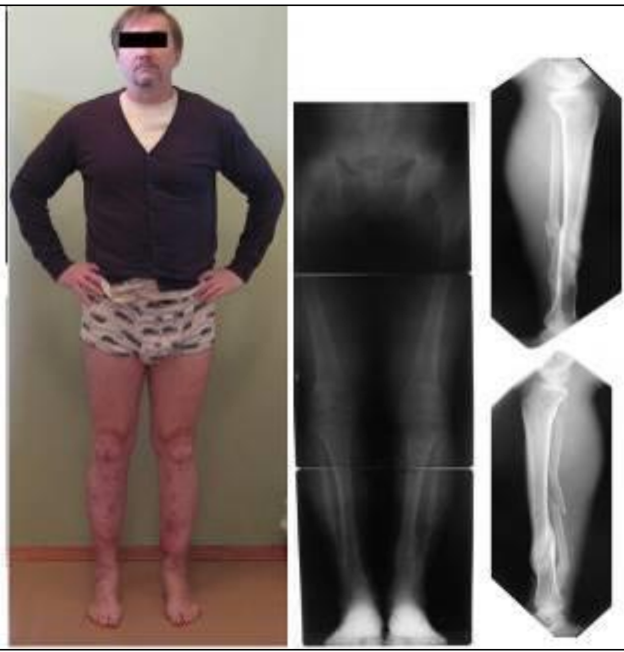
e


Step 13
Strut length change
Rate of correction 1 mm/day
Calculate
Recommended number of days 22
once a day
twice a day
four times a day
Back
Show
Print
Clean
Name, age: Egorov I.M., 47 y.o.
Diagnosis: Lower leg deformity
Case history: 5078
Date: 16.11.2009
Mode: Four time a day
Day Str1 Str2 Str3 Str4 Str5 Str6
Day: 0 137,00 150,00 151,00 133,00 153,00 140,00
8AM +0 -1 +1 +0 +1 -1
12AM +1 -1 +2 +0 +1 -1
4PM +0 -1 +1 -1 +1 -1
8PM +1 -1 +1 +0 +1 -1
Mode: Four times a day
In this mode strut length is controlled using 8 longitudinal lines on external cylinder and one line on internal cylinder.
Turn from one line to the next one corresponds to change of strut length by 0.25 mm:
(+) - for lengthening and (-) - for shortening.
+45°
-45°
+0.25 mm
- 0.25 mm
Turn from line to line = 45 deg. = 0.25 mm.
Eight turns from line to line = 360 deg. = 2 mm.
The software will calculate number of turns from line to line at 8AM, 12AM, 4PM and 8PM - recommended time for changing strut length.

f

g

h



i

Fig. 83. Photographs and roentgenograms of patient E. before, during and after the treatment

6.2.2 Femur shaft deformity correction

28 y.o. patient K. was hospitalized with the diagnosis: Posttraumatic complex two-level deformation of the right femur with shortening 4 cm (Fig. 84a).

The patient was operated: two-level osteotomy with applying two Ortho-SUV Frames (Fig. 84b):

$$\frac{\text{I,10,90; I,8,90}}{\text{¼ 200}} - \frac{\text{II,9,90; III,10,90}}{\text{2/3 220}} - \text{O-SUV} - \frac{\text{IV,9,90; V,10,90}}{\text{200}} - \text{O-SUV} - \frac{\text{VII,9,90;VIII,}\mathbf{3}\text{-9; VIII,8,90; VIII,4,90}}{\text{180}}$$

In calculation bone fragment markers were drawn in a projection of anatomic axes of bone fragments. Calculations were made separately for each of levels of deformation (Fig. 84c).

To find time necessary for deformity correction, Structures at Risk (SAR) were designated in Step 12.

Deformity correction was performed and the correct position of mechanical axis of femur restored according to the software calculations (Fig. 84f).

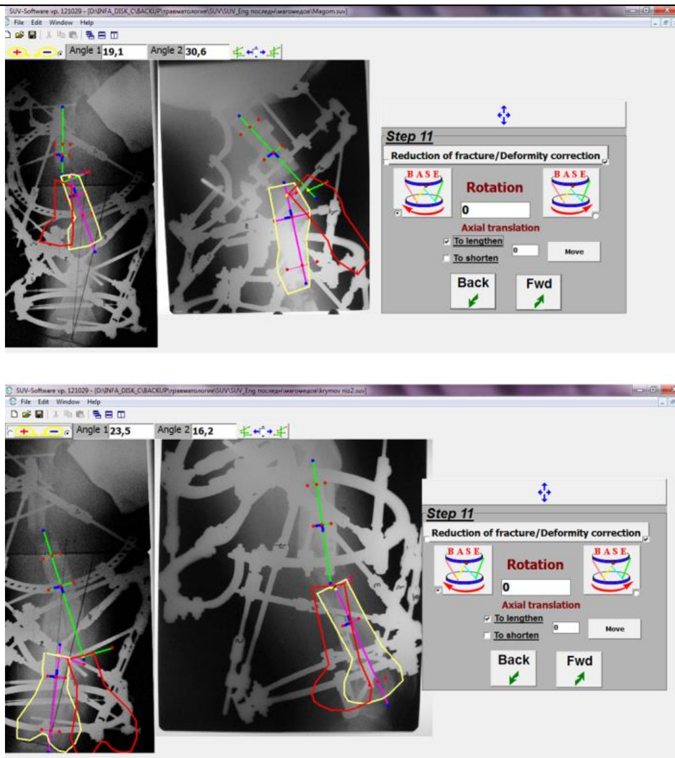
After deformity correction struts were replaced for Ilizarov hinges (Fig. 84g).

In 2 months after the beginning of the fixation period module transformation of the device was executed (Fig. 84h).

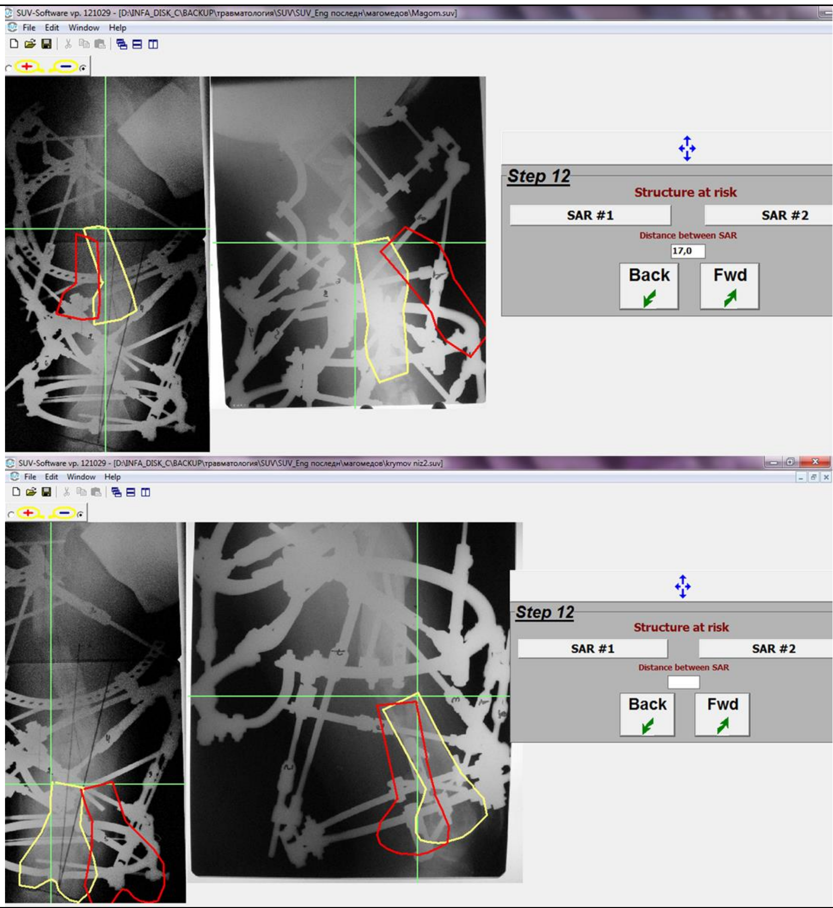
In 130 days after the beginning of the fixation period the frame was removed (Fig. 84i).

a

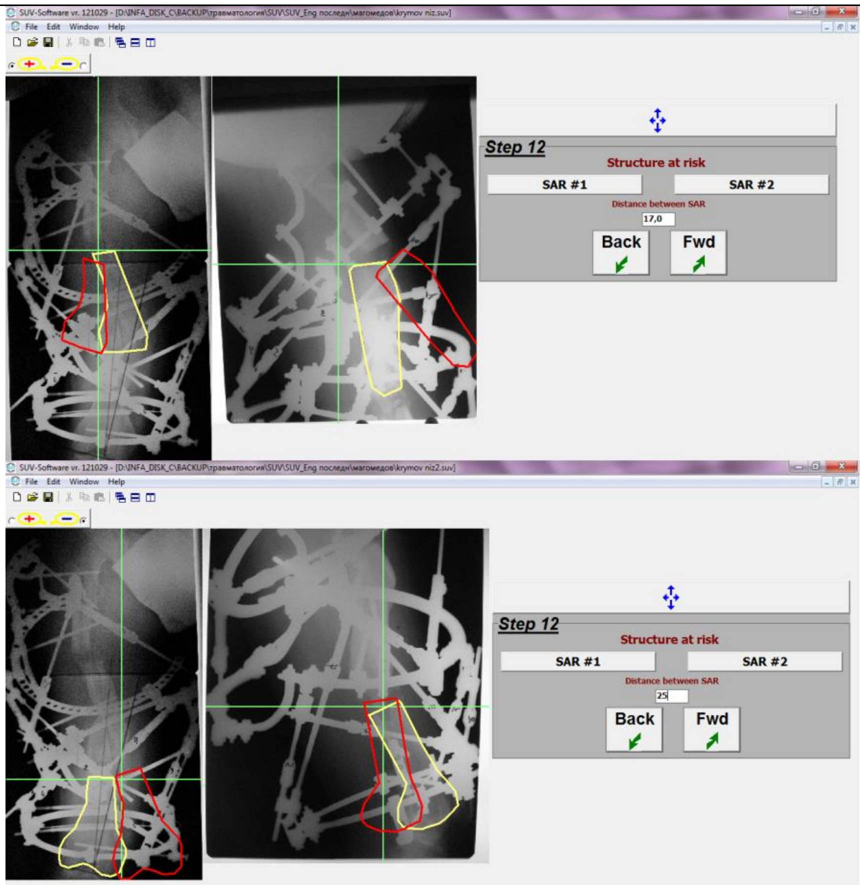
b


Angle 1 19,1
Angle 2 30,6
Step 11
Reduction of fracture/Deformity correction
BASE
Rotation
BASE
0
Axial translation
To lengthen
To shorten
0
Move
Back
Fwd
Angle 1 23,5
Angle 2 16,2
Step 11
Reduction of fracture/Deformity correction
BASE
Rotation
BASE
0
Axial translation
To lengthen
To shorten
0
Move
Back
Fwd

c

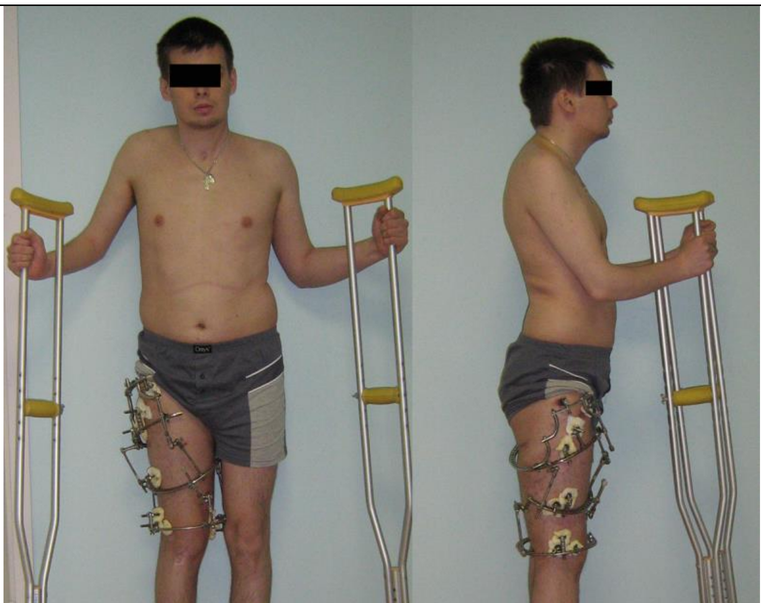

File Edit Window Help
Step 12
Structure at risk
SAR #1
SAR #2
Distance between SAR
17,0
Back
Fwd
File Edit Window Help
Step 12
Structure at risk
SAR #1
SAR #2
Distance between SAR
Back
Fwd

d


File Edit Window Help
Step 12
Structure at risk
SAR #1
SAR #2
Distance between SAR
17,0
Back
Fwd
File Edit Window Help
Step 12
Structure at risk
SAR #1
SAR #2
Distance between SAR
25
Back
Fwd

e

f



g

h

i

Fig. 84. Photographs and roentgenograms of patient E. Before, during and after treatment

6.3 Application of Ortho-SUV Frame in metaphyseal deformity

19 y.o. women K. was hospitalized with the diagnosis: distal metaepiphyseal nonunion of the right tibia. Four-component, three-planar

deformity of the right lower leg (Fig. 85a). United left femur fracture, treated by external fixation device.

As the first stage external fixation using Ortho-SUV Frame was done (Fig. 85 b,c):

$$\frac{\text{I,}\mathbf{9}\text{-3; I,}\mathbf{4}\text{-10; II,1,90}}{150} - \frac{\text{IV,}\mathbf{10}\text{-4; V,2,90}}{150} - \text{Ortho-SUV} -$$

$$- \frac{\text{VII(}\mathbf{8}\text{-2)8-2; VIII,}\mathbf{4}\text{-10}}{150} - \frac{\text{calc., }\mathbf{8}\text{-2; calc.,}\mathbf{4}\text{ -10; m/tars.,}\mathbf{V}\text{- m/tars.,I}}{\text{horseshoe-shaped support}}$$

While working with computer program basic fragment markers using centrators were drawn in projection of anatomical axes of proximal fragment on AP and lateral views. It was not difficult because of large size of this fragment.

It was not possible to use centrators due to the shortness of distal fragment (35 mm). To identify anatomic axes the “blue angle” was used. Positions of crossing points of ankle joint lines and anatomic axes for AP and lateral view are known (Paley D., 2005). In Step 10 the centrator with blue angle was placed on the joint line in a way that apex of the blue angle was localized in the centre of joint line. After that, using options of the program, necessary value of blue angle was set: 89 deg. for the AP and 80deg. - for lateral view. As a result the axial line of the bone fragment marker corresponded to anatomic axis of distal fragment (Fig. 85d,e).

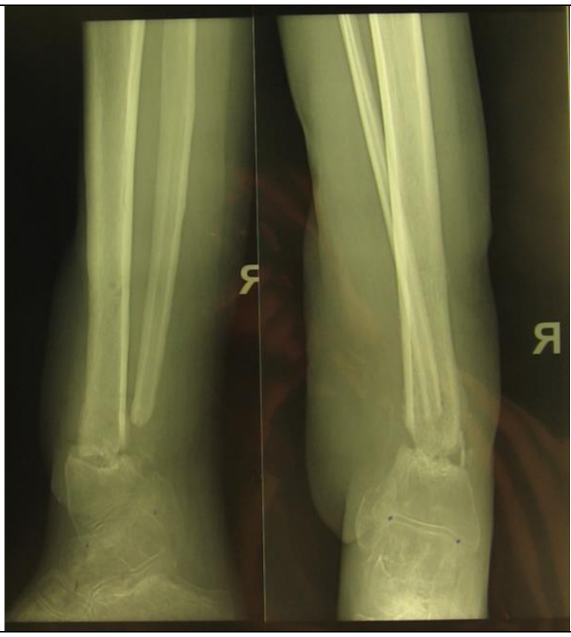
To find time necessary for deformity correction, Structures at Risk (SAR) were designated.

SAR #1 was put on the osteotomy line, at where the mobile fragment during its movement will cover the *longest distance* (Fig. 85f). SAR #2 was put in the projection at where main vessels and nerves will get its maximal stretching (Fig. 85g).

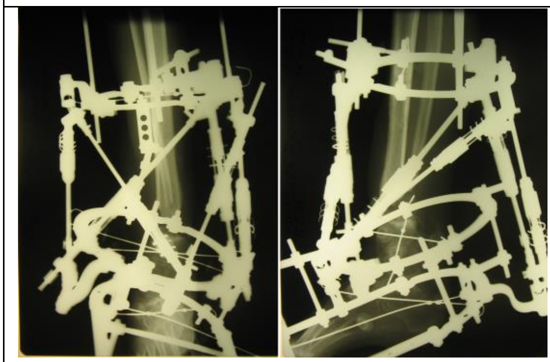
In Step 12 the rate of deformity correction - 1 mm per day – was entered. After “Calculate” button was pressed, program calculated the recommended number of days required for correction of the deformity. When button «Show» had been pressed, in the lower right field of the display a table appeared displaying the values of daily length change for each strut (Fig. 85h). This table was printed out and given to the patient.

Deformity correction was done according to software calculation (Fig. 85i). After deformity correction struts were replaced for Ilizarov hinges (Fig. 85j). The second stage was bone grafting of non-union site and corticotomy for lower leg lengthening at level II (Fig. 85k).

The frame was removed in 207 days after bone grafting (Fig. 85l).

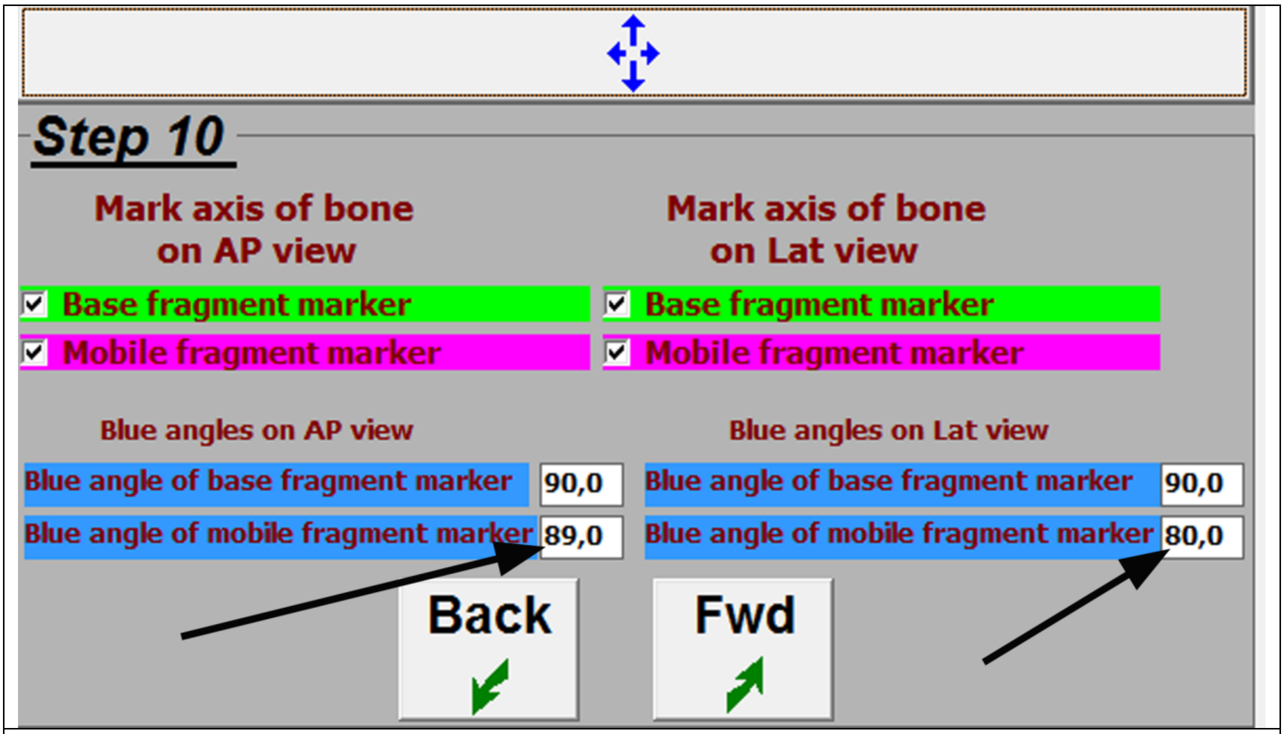


a

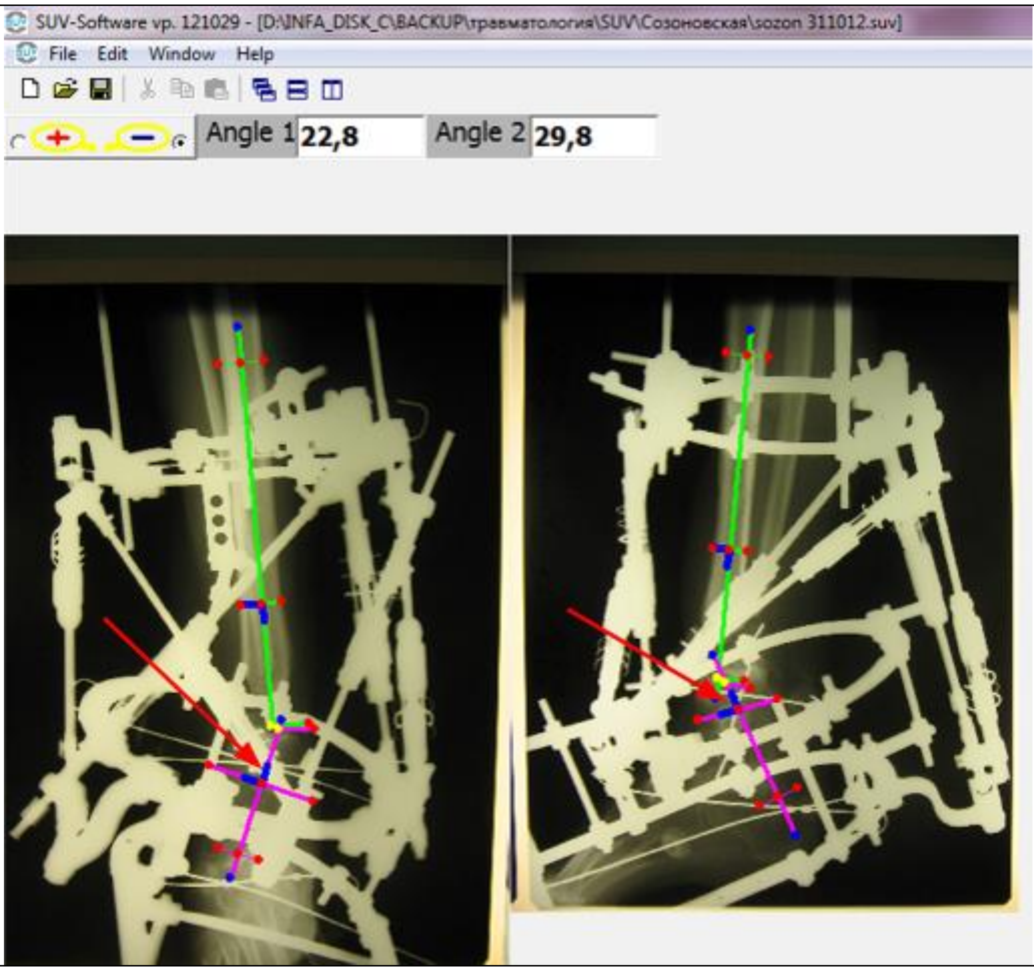


b

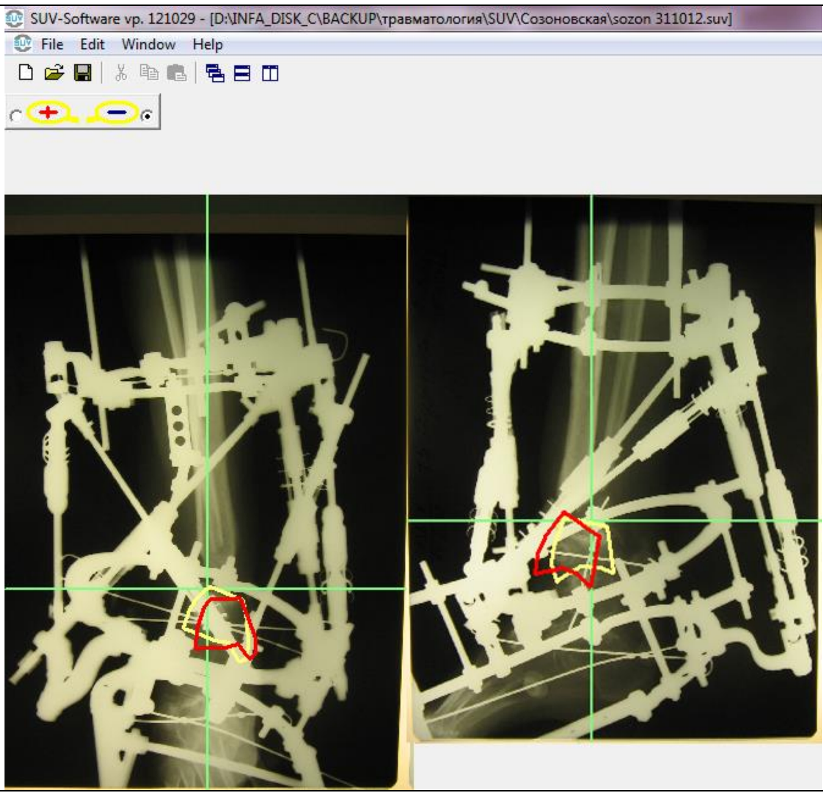
c


Step 10
Mark axis of bone on AP view
Mark axis of bone on Lat view
Base fragment marker
Mobile fragment marker
Base fragment marker
Mobile fragment marker
Blue angles on AP view
Blue angles on Lat view
Blue angle of base fragment marker
90,0
Blue angle of mobile fragment marker
89,0
Blue angle of base fragment marker
90,0
Blue angle of mobile fragment marker
80,0
Back
Fwd

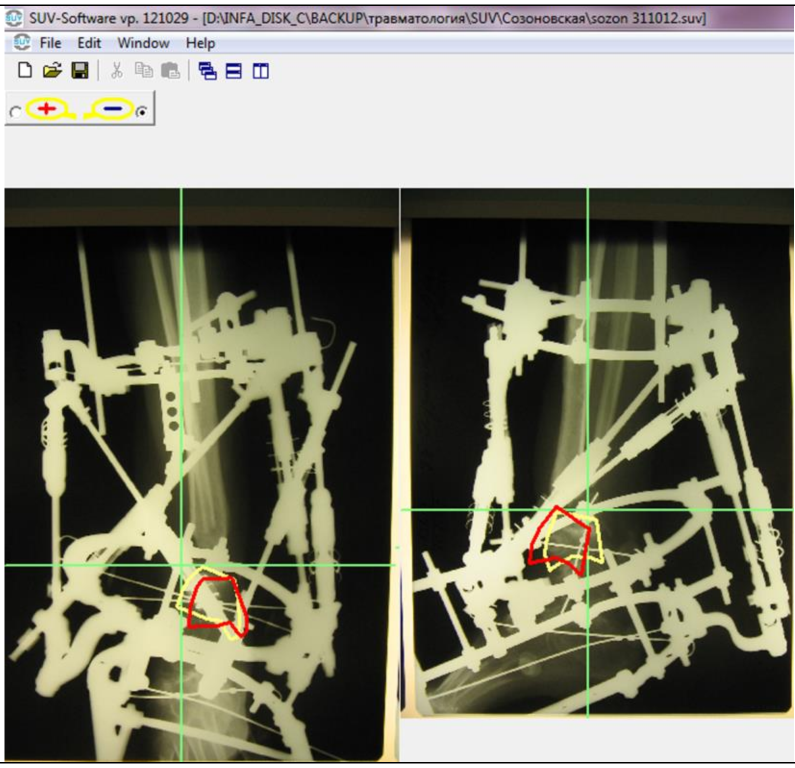
d


SUV-Software vp. 121029 - [D:\INFA_DISK_C\BACKUP\травматология\SUV\Созоновская\sozon 311012.suv]
File
Edit
Window
Help
Angle 1
22,8
Angle 2
29,8

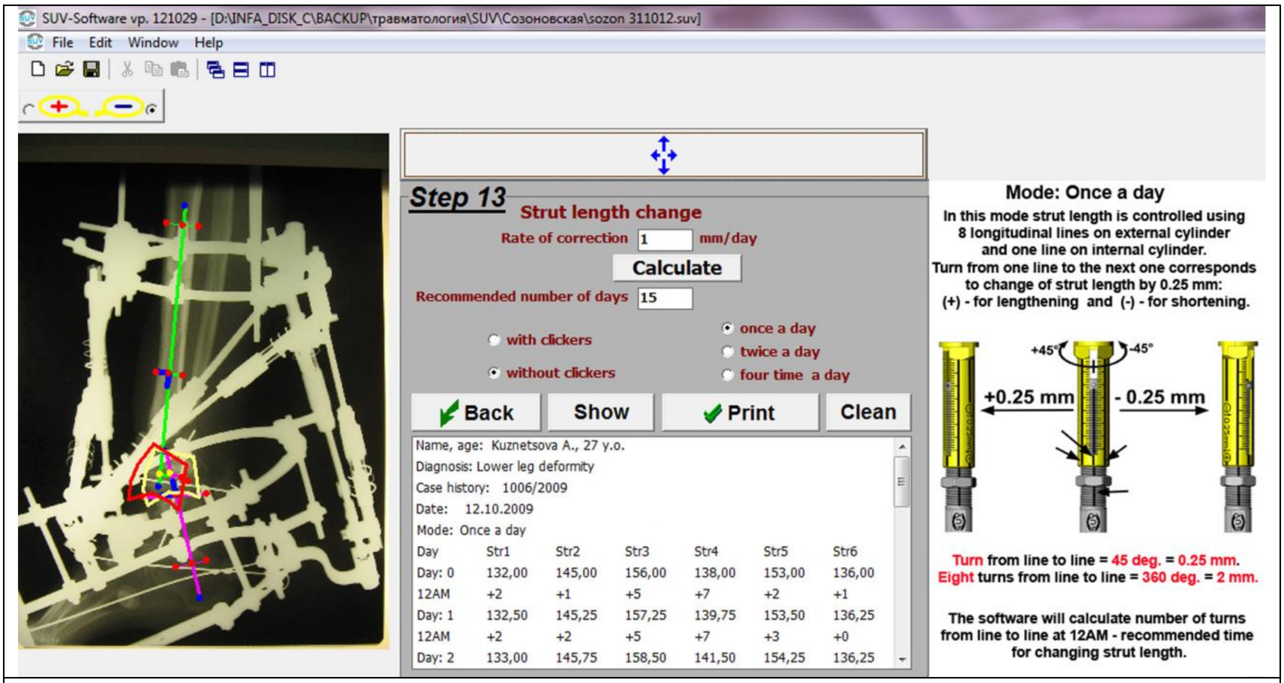
e


SUV-Software vp. 121029 - [D:\INFA_DISK_C\BACKUP\травматология\SUV\Созоновская\sozon 311012.suv]
File Edit Window Help

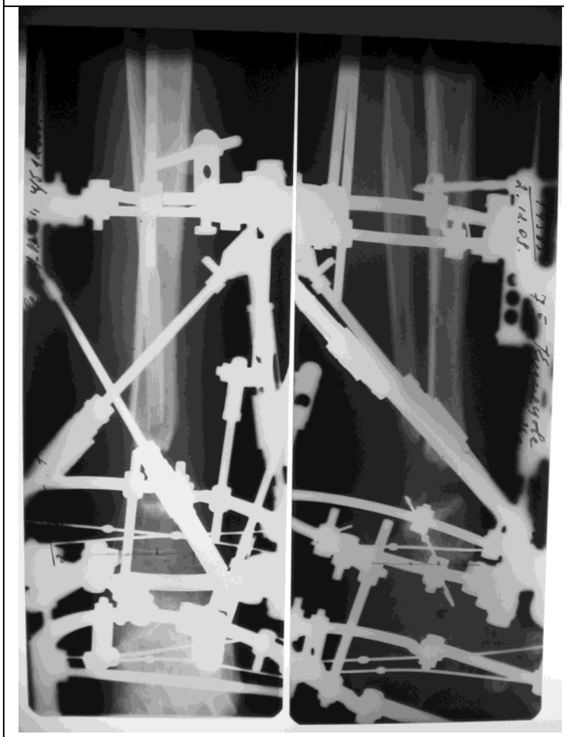
f


SUV-Software vp. 121029 - [D:\INFA_DISK_C\BACKUP\травматология\SUV\Созоновская\sozon 311012.suv]
File Edit Window Help

g


SUV-Software vp. 121029 - [D:\INFA_DISK_C\BACKUP\травматология\SUV\Созоновская\sozon 311012.suv]
File Edit Window Help
Step 13
Strut length change
Rate of correction 1 mm/day
Calculate
Recommended number of days 15
with clickers
without clickers
once a day
twice a day
four time a day
Back
Show
Print
Clean
Name, age: Kuznetsova A., 27 y.o.
Diagnosis: Lower leg deformity
Case history: 1006/2009
Date: 12.10.2009
Mode: Once a day
Day Str1 Str2 Str3 Str4 Str5 Str6
Day: 0 132,00 145,00 156,00 138,00 153,00 136,00
12AM +2 +1 +5 +7 +2 +1
Day: 1 132,50 145,25 157,25 139,75 153,50 136,25
12AM +2 +2 +5 +7 +3 +0
Day: 2 133,00 145,75 158,50 141,50 154,25 136,25
Mode: Once a day
In this mode strut length is controlled using 8 longitudinal lines on external cylinder and one line on internal cylinder.
Turn from one line to the next one corresponds to change of strut length by 0.25 mm:
(+) - for lengthening and (-) - for shortening.
+45°
-45°
+0.25 mm
- 0.25 mm
Turn from line to line = 45 deg. = 0.25 mm.
Eight turns from line to line = 360 deg. = 2 mm.
The software will calculate number of turns from line to line at 12AM - recommended time for changing strut length.

h



i

j

k

l

Fig. 85. Photographs and photoroentgenograms of patient K. **a -** before treatment. **b,c** - after Ortho-SUV Frame applying. **d** – arrows point at dialog box fields where values of epimetaphyseal (anatomic) angles have been entered. **e –** arrows point at blue angles. Because due value of blue angles were entered, axial lines of bone fragment markers are located precisely in projection of anatomic axes of distal fragment in frontal and sagittal planes. **f,g** – identification of structures at risk: SAR #1 and SAR #2. **h** - results of software calculation. **i-k** - result of correction. l - result of treatment

6.4 Application of Ortho-SUV Frame in Foot Deformity Correction

19 y.o. women Z. was hospitalized with the diagnosis: complex deformity of right foot with 5 cm shortening (Fig. 86a).

At first stage, V-shaped foot osteotomy and applying of two Ortho-SUV Frames was done (Fig. 86b):

____ – VII 11,110; VIII,**4**-10; VIII,**8**-2(8-2) –Ortho-SUV– calc.**4**-10; calc.**8**-2 –0–
120 120 2/3 110

–0– tars.**4**-10; tars.**8**-2 –Ortho-SUV– m/tars.**I**- m/tars.II; m/tars.**V**- m/tars.III -- ____
120 120 120

Free (without transosseous elements) proximal and distal rings were used to facilitate of struts fixation.

Calculations were done separately for each frame. The first frame and the first calculation were used for hindfoot deformity correction (Fig. 86c). The second device and the second calculation were used for midfoot deformity correction (Fig. 86d).

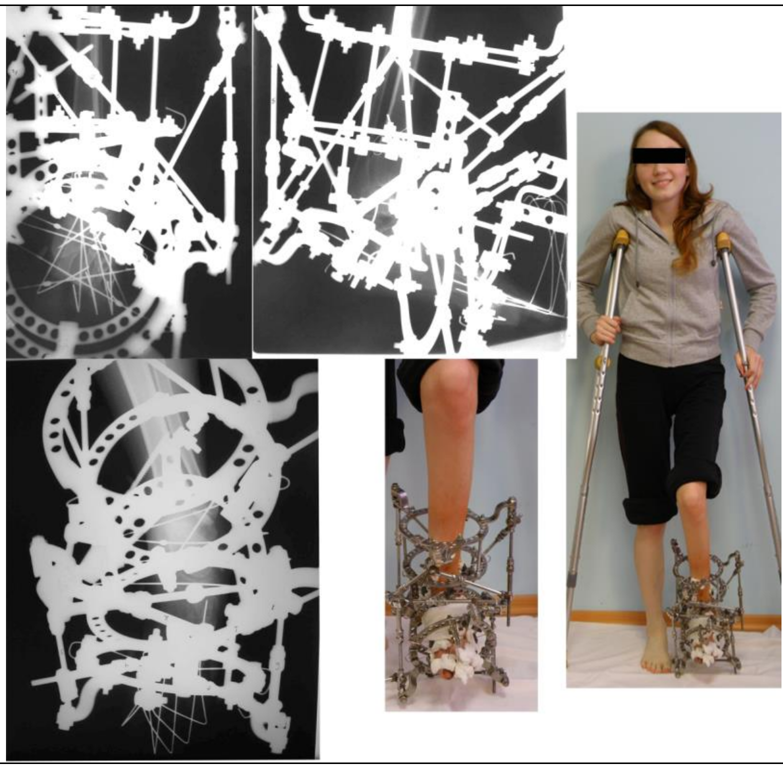
Correction of deformation was executed precisely according to calculations (Fig. 86e). After deformity correction frame module transformation was done: struts were substituted for Ilizarov hinges and free supports were removed (Fig. 86f). Final configuration of the device is:

VII 11,110; VIII,**4**-10; VIII,**8**-2(8-2) –o– calc.**4**-10; calc.**8**-2 –o–
120 2/3 110

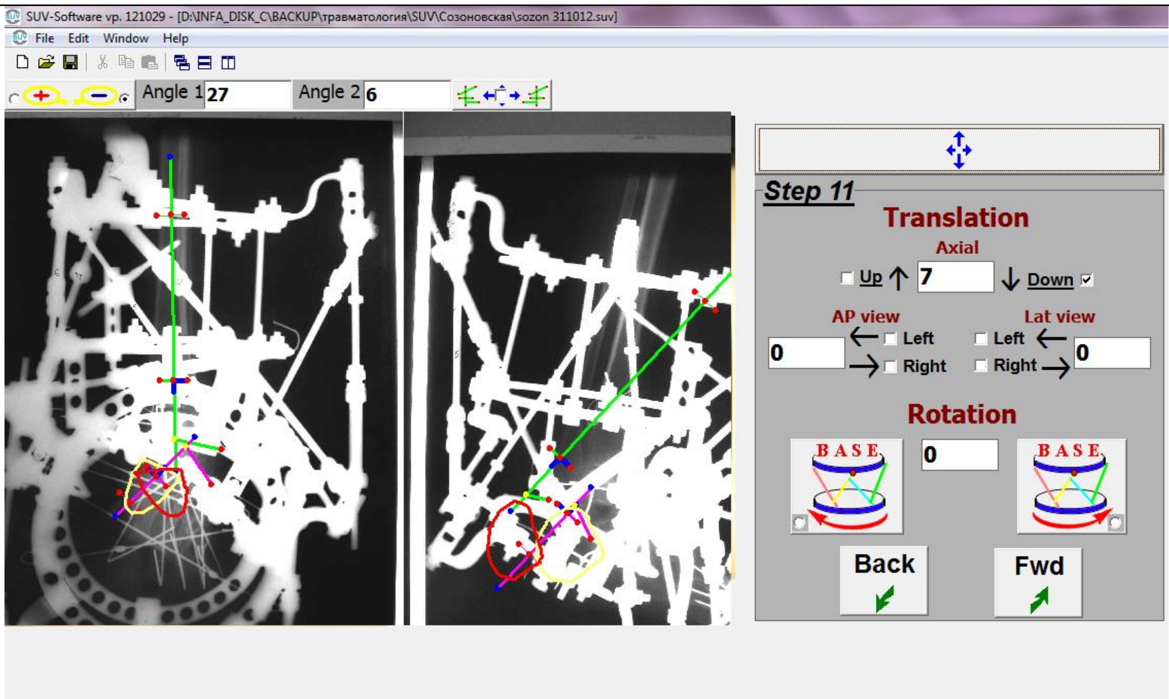
–o– tars.**4**-10; tars.**8**-2 –o– m/tars.**I**- m/tars.II; m/tars.**V**- m/tars.III
120 120

The period of fixation lasted 4 months. In 6.5 months after operation frame was demounted (Fig. 86g).

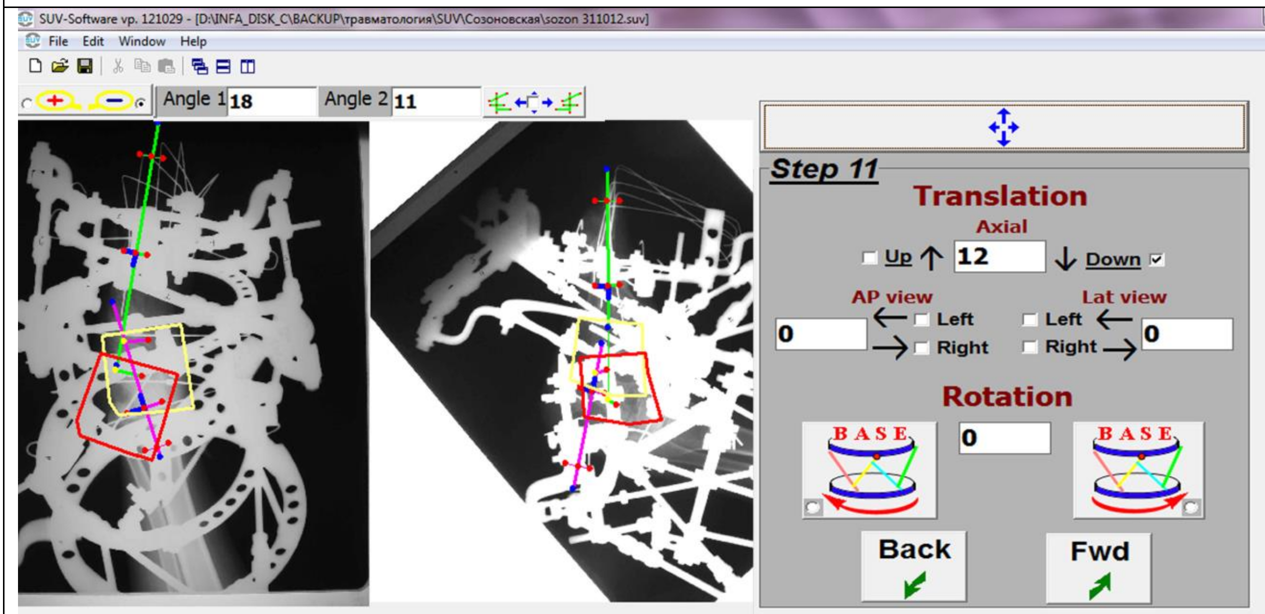
a



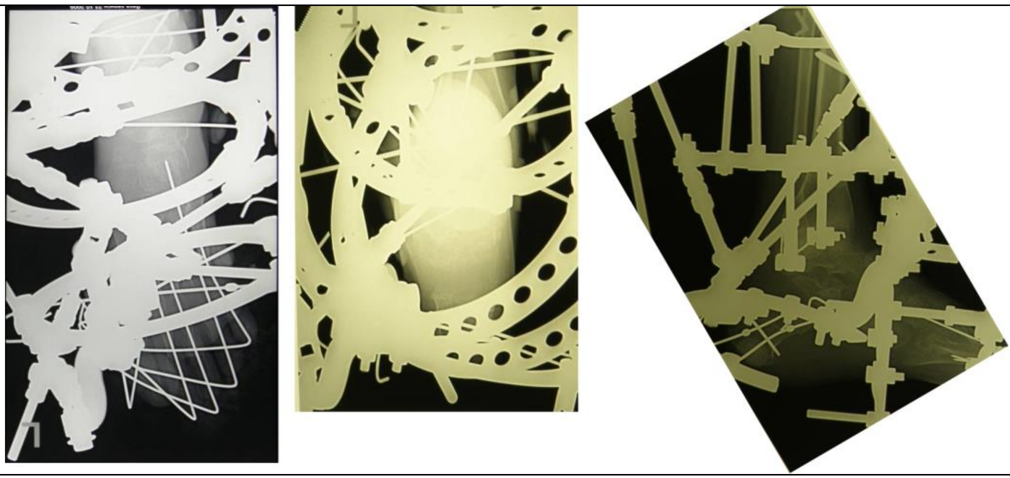
b


SUV-Software vp. 121029 - [D:\INFA_DISK_C\BACKUP\травматология\SUV\Созоновская\sozon 311012.suv]
File Edit Window Help
Angle 1 27
Angle 2 6
Step 11
Translation
Axial
Up
7
Down
AP view
Left
Right
0
Lat view
Left
Right
0
Rotation
BASE
0
BASE
Back
Fwd

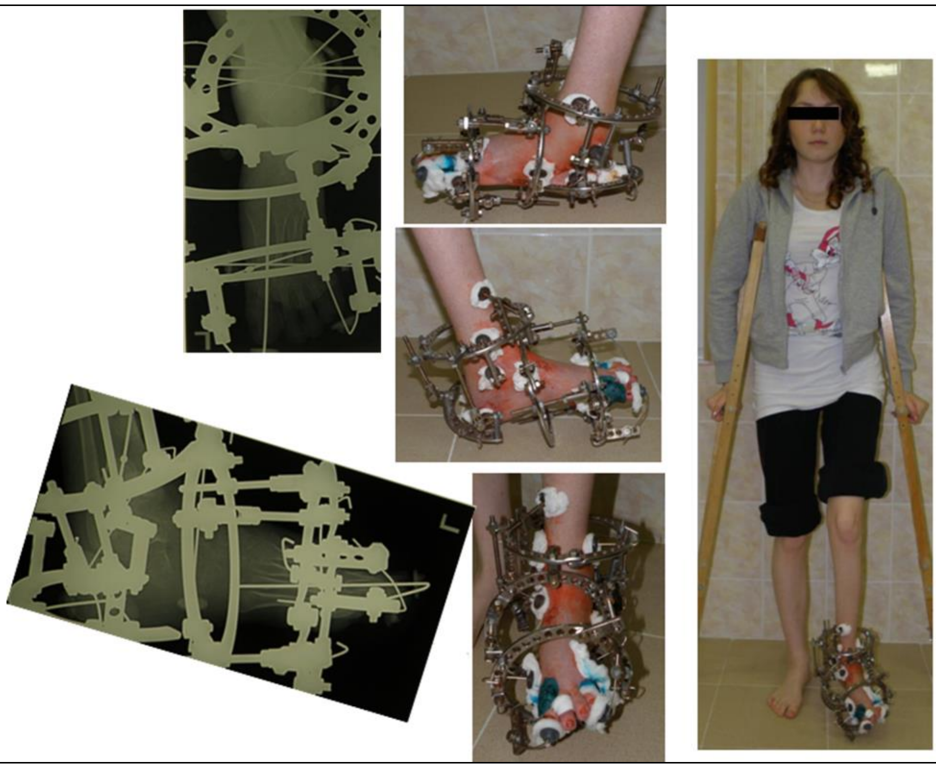
c


SUV-Software vp. 121029 - [D:\INFA_DISK_C\BACKUP\травматология\SUV\Созоновская\sozon 311012.suv]
File Edit Window Help
Angle 1 18
Angle 2 11
Step 11
Translation
Axial
Up
12
Down
AP view
Left
Right
0
Lat view
Left
Right
0
Rotation
BASE
0
BASE
Back
Fwd

d



e



f

g

Fig. 86. Photographs and photoroentgenograms of patient Z. before, during and after the treatment

6.5 Application of Ortho-SUV Frame in Treatment of Knee Joint Stiffness

48 y.o. women P. was hospitalized with the diagnosis: consolidated fracture of left femur, severe extension stiffness of left knee joint (15/0/0) (Fig. 87a).

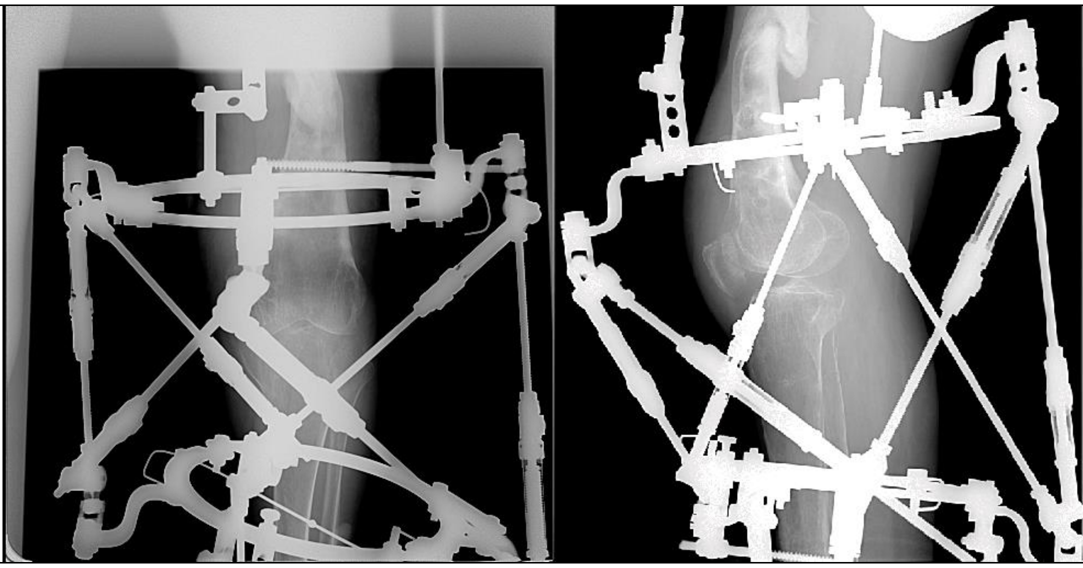
Judet procedure was performed followed by Ortho-SUV Frame application (Fig. 87b):

$\underline{\text{III,10,}\underset{\text{¼ 200}}{\text{90}}\text{; IV,8,90}}$ __ $\underline{\text{VII,}\mathbf{3}\text{-9; }\underset{180}{\text{VII}}\text{,8,90}}$ –Ortho-SUV–

– $\underline{\text{III,}\mathbf{4}\text{-10; }\underset{150}{\text{IV}}\text{,1,80}}$ __ $\underline{\text{VIII(}\mathbf{8}\text{-2)}\underset{150}{\text{8}}\text{-2; VIII, }\mathbf{4}\text{-10}}$

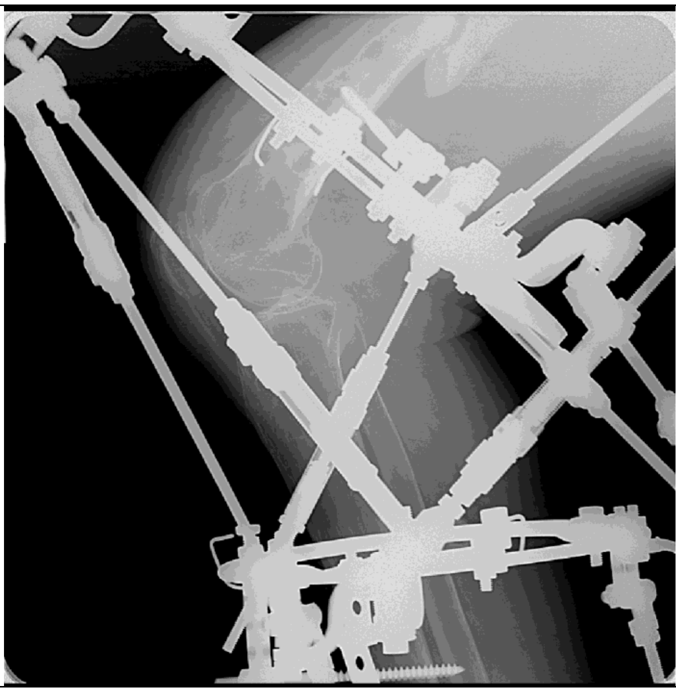
While performing program calculations, to identify the motion curve of the joint end of tibia relatively to femur, the Iwaki's knee joint motions kinematics was used [Iwaki H., 2000]. Proceeding from these calculations, knee joint flexion up to 90 degrees was completed in 12 days (Fig. 87c,d). The cycle "90 deg. flexion – knee zero position" was then performed, using Ortho-SUV Frame, twice a day during the following 5 days – ten cycles in all. Then struts were removed and the patient performed active motions in knee joint (Fig. 87e). After that the external fixation device was removed. In remote period the ROM in knee joint was 90/0/0 (Fig. 87f).

a



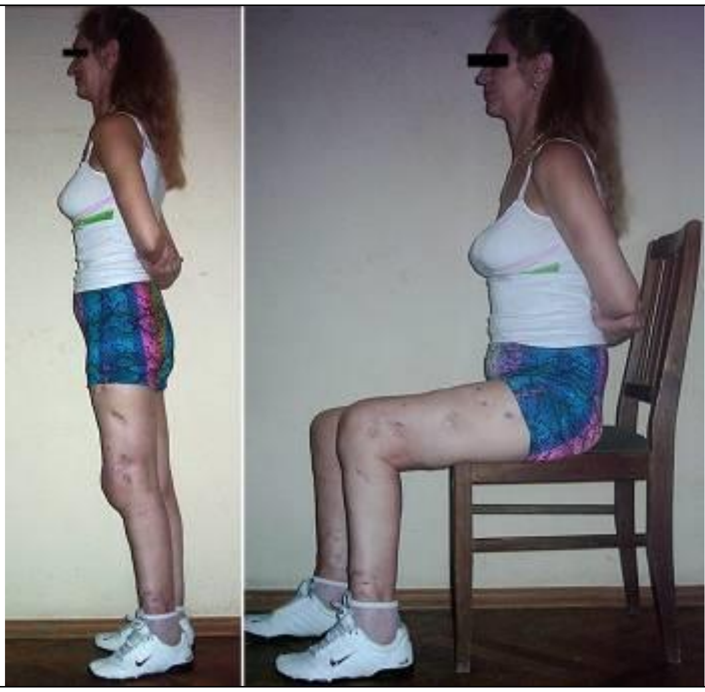
b

c



d

e



f

Fig. 87. Photographs and photoroentgenograms of patient P. before, during, and after the treatment. Note the correct interrelations in the knee joint during flexion using Ortho-SUV Frame

7. Tips and Tricks for Using the Ortho-SUV Frame

Table 1 lists the possible specific difficulties that can occur while working with the Ortho-SUV Frame, as well as tips for their avoidance and elimination.

As the table makes clear, almost all possible complications are the result of incorrect use of the hardware and (or) software. However, if despite consultation of the table the cause cannot be determined and difficulties in working with the program are experienced, the operator is advised to archive the case folder (AP, Lat view, and "**.suv"-file) and e-mail it to orthosuv@gmail.com. The cover letter should include a detailed explanation of the nature of the problem encountered. This is one reason why it is essential to save the file after each step of the program.

Table 1. Complications occurring with use of Ortho-SUV Frame

#	Complications	Main causes	Prophylaxis	Elimination
1	During assembly of the external fixation frame, it is difficult to connect the struts with each other.	The initial arrangement of the struts differs from that shown in Fig. 14a,b .	Arrange the struts as shown in Fig. 14a,b . It is necessary to use algorithm of strut assembly, submitted at Fig. 21a-i.	Prior to the assembly of the external fixation frame, arrange the struts as shown in Fig. 14a,b. Use algorithm of strut assembly, submitted at Fig. 21a-i.
2	Due to the short distance	The distance between the supports is <120–	1. The distance between the supports,	1. Partial reassembly of the external fixation

	between the basic supports, it is difficult or impossible to arrange the struts.	150 mm.	if possible, must not be <150 mm. 2. Use Z-shaped plates to fix the struts (Figs. 15c, 17b) 3. Use stabilizing supports to fix the struts (Fig. 17c,d)	frame 2. Strut fixation of using Z-shaped plates (Figs. 15c, 17b) 3. Fixation of some of the struts to the stabilizing supports (Fig. 17c,d)
3	Loading the AP image (Step 2) does not result in its appearance in the program window.	A feature of the program is that both roentgenograms appear only after the second, lateral one has been loaded.	-	-
4	During reloading of the file (with all steps of the program previously completed), at Step 3, the previously loaded roentgenograms are not visible.	This is a feature of the program: you will be able to work with the images on all of the following steps.	-	-
5	It is not possible to define the number of struts and joints necessary and thus to proceed to the next step on the X-ray image (Steps 6 and 7); it is difficult to define the numbers of struts and joints.	1. The X-rays are made on narrow film and do not include all struts and joints. 2. The images were obtained without the use of strut markers (Fig. 32).	1. The X-ray field must include all struts and joints. 2. Strut markers must be placed on the struts prior to X-ray imaging (Fig. 32).	X-rays must be retaken
6	In spite of all struts and joints having been marked in Step 6 or 7, the program does not allow continuation to the next step.	The focal distance and (or) the center of the beam value was not entered.	Entering all the data required in this window	Enter the focal distance and the beam center
7	After Step 7 has	1. Incorrect assembly	1. Correct assembly of	1. Partial re-assembly

	been completed, the program shows red lines that do not coincide with the strut projections s, ranging from the non-coincidence of one of the lines to the total displacement of all lines relating to the external fixation frame. In the extreme case, the red lines are beyond the visible field.	of the external fixation frame: first of all, lack of adherence to the “logo rule” (Fig. 18) and the “watch rule” (Fig. 19). 2. Incorrectly entered lengths of the struts and sides of the triangles or entry of the values in cm (Step 1). 3. Incorrect scaling (Steps 4, 5): the length of the known section is <80 mm and (or) the length of the known section was entered in cm. 4. Incorrectly entered focal distance (Steps 6, 7) or the focal distance was entered in cm. 5. Incorrectly marked numbers of the struts and (or) joints, i.e., lack of correspondence to the assembly of the external fixation frame (Steps 6, 7). 6. Coincidence of the red lines with the projections of the struts depends on the exact and correct completion of Steps 1–7.	the external fixation frame 2. Exactly entered values of the lengths of the struts and sides of the triangles in mm. 3. Exact value of the known section length entered in mm. 4. Exact value of the focal distance entered in mm. 5. Marking the numbers of the struts numbers and (or) joints according to the assembly of the external fixation frame by using the strut markers when obtaining an X-ray image (Fig. 32). 6. Control of whether the values have been entered correctly in the completion of Steps 1–7. If the AP and lateral roentgenograms were not taken in orthogonal projections, then on Steps 6 and 7 the maximal possible number of struts and joints must be marked.	of the external fi xation frame, which requires an additional X-ray image. 2. Exact lengths of the struts and sides of the triangles are entered in mm. 3. Exact length of the known section entered in mm. 4. Exact focal distance entered in mm. 5. Entering the numbers of the struts and joints according to the assembly of the external fixation frame. 6. Thorough control of the data entered in Steps 1–7. Return to Steps 6 and 7 and mark the maximally possible number of struts and joints.
8	In advancing to Step 10, the program shows a dialog window	1. Different lengths of the bone contours (Step 8) of the mobile bone fragment on the	1. The lengths of the bone contours on the AP and lateral views must be equal.	1. Erase the bone contours and draw them again, this time of equal length.

	"Precise the anatomical axes sizes."	AP and lateral views. 2. The anatomic axes (Step 9) of the mobile bone fragment on the AP and (or) lateral views do not sufficiently exceed the upper or lower margins of the bone contour.	2. The anatomic axes must exceed the margins of the bone contours by 20–30 mm.	2. I f it is impossible to draw the anatomic axis above the distal end of the bone contour (short X-ray image). return to Step 8, erase the bone contour, and draw a new one, which must be shorter than the initial bone contour.
9	When moving from Step 11 to Step 12 program shows a dialogue window "Improper data".	In the field "Rotation" direction and(or) value of rotation were not specified.	Any numerical value of rotation must be entered into the field of value of rotation. In addition either window, indicating a direction of mobile fragment rotation, must be ticked. If rotation is not required, "0" (zero) and any direction of rotation must be entered.	It is necessary to enter value of rotation and its direction.
10	When moving from Step 11 to Step 12 program shows a dialogue window "Click both pointers".	The button "plane-parallel moving" has been clicked (Fig. 68) and(or) the command "to confirm moving" ("click pointers") has not been executed (Fig. 72).	If options "Plane-parallel moving" and (or) "Angulation" have been used, the command "*to confirm moving*" ("click pointers") must be done before going to Step 12 (Fig. 68). The button "plane-parallel moving" must not be clicked (Fig. 72).	Switch off the button "plane-parallel moving" (Fig. 68) and execute the command "to confirm moving" ("click pointers") (Fig. 72).
11	After the "Calculate" button has been clicked to calculate the number of days required for the deformity correction or fracture	To calculate the number of days required for the deformity correction or fracture reduction, the program always uses the structures at risk points (Figs. 73, 74 and 75). If these have not been set, the	Do not forget to exactly locate both structures at risk points (Step 12).	Return to Step 11 and exactly set the structures at risk points (Figs. 73, 74 and 75).

	reduction (Step 13), the program gives an obviously incorrect result: for example, 17 days for a 5-mm distraction.	program considers the default settings for these structures, which cannot be applicable to the target case.		
12	During deformity correction, the struts begin to press on the soft tissues or on the outstanding ends of the half-pins.	Incorrect initial assembly of the external fixation frame	During surgery planning, it is essential to consider the direction in which the distal main support and struts will be moved.	Partial re-assembly of the external fixation frame
13	In a maximal distraction during correction of the deformity, the threaded rod (Fig. 7) has completely dislocated itself from the strut length changing unit (Fig. 9); disconnection of the unit and the threaded rod has occurred, thus destabilizing the external fixation frame.	There is no thread on one of the ends of the threaded rods packed in the Ortho-SUV Frame set, which precludes disconnection of the strut length changing unit and the threaded rod. If this complication has occurred, the rods being used in the external fixation frame assembly do not belong to the Ortho-SUV set.	1. Use only the threaded rods packed in the Ortho-SUV set. 2. The threaded bush of the strut length changing unit (Fig. 9) has a slot. It can be used to control the position of the peripheral end of the threaded rod.	Partial re-assembly of the external fixation frame, replacing the threaded rod by a longer one.
14	On the control X-ray image, an exact deformity correction not shown; the location of the distal fragment does not fully correlate with that of the red bone contour	1. The location of the distal fragment was set by the user in Step 11: therefore, at maximal magnification, examine the location of the red bone contour relative to the basic (proximal) fragment.	1. The yellow bone contour (Step 8) must exactly coincide with the contours of the mobile bone fragment. In completing deformity correction or fracture reduction planning (Step 11), the location of the red bone contour of the	1. Additional program calculation and elimination of the residual displacement

	(Step 11).	2. Unstable fixation of the bone fragments by the proximal and (or) distal external fixation unit. As a rule, the bone fragment relating to the support becomes displaced due to the deformity of the transosseous elements. 3. X-ray projections taken before and after the deformity correction do not coincide.	proximal fragment must be visually controlled using maximal magnification. 2. Fixation of the proximal and distal bone fragments must be stable and exclude the possibility of fragment displacement relative to the appropriate supports. 3. Take X-rays in the same views	2. Reassembly of the external fixation frame (stabilizing the supports), repeated calculation in the program and elimination of the residual displacement 3. Control X-ray images are obtained in views different from those that enabled the detection of the additional displacement of the fragments. Perform an additional calculation in the program and eliminate the residual displacement.
15	The control X-ray image shows that the fragments have interconnected, which prevents fracture reduction or deformity correction. Thus, further changes in strut length will result in the deformation of not only the bone fragments but of the whole external fixation frame as well.	Note that the program calculates the integral trajectory for the bone fragment reduction, i.e., according to the shortest distance. Thus, if there is axial displacement of the bone fragments (the proximal end of the distal fragment is higher than the distal end of the proximal fragment) and attempts are made to eliminate the translation, the fragments will become inevitably interconnected.	If the proximal end of the distal fragment is higher than the distal end of the proximal fragment, deformity correction (fracture reduction) must be performed in two stages: (1) distraction to provide a 3–4 mm diastasis between the bone fragments (program calculation planned for distraction); (2) residual displacement is eliminated (the second calculation in the program) (Fig. 71).	The first stage is distraction to achieve 3-4 mm gap between fragments. The second stage is residual deformity correction (Fig. 71).
16	After the work is complete the program does not shut down	The hasp-key was removed before the program was shut down.	First shut down the program and only after that remove the hasp- key.	Insert the hasp-key in to the USB-port and after that shut down the program.

8. Instead of the conclusion

8.1. Legalization

For any questions concerning copyright and license agreement registration apply to:

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8.2. Ortho-SUV Frame training courses and workshops

Complete information concerning training courses for the Ortho-SUV Frame can be found at http://ortho-suv.org, http://rniito.org/solomin, http://www.rniito.org/download/ortho-suv-Iliz-course-9-engl.pdf and http://www.rniito.org/download/ortho-suv-course-4-eng.pdf .

To the attention of scientists and orthopedic surgeons

We invite you to take part in scientific and practical work, associated with the Ortho-SUV Frame application and improvement. Further information can be send to Prof. Leonid N. Solomin: Vreden Russian Research Institute of Traumatology and Orthopedics; solomin.leonid@gmail.com, http://rniito.org/solomin

8.3. Where to acquire

All information can be taken at web-sites of Ortho-SUV Ltd. and S.H. Pitkar Orthotools Pvt. Ltd:

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ISO 9001,ISO13485 and Indian FDA approved company
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http://pitkar.com

ART OF DEFORMITY SUV CORRECTION

http://ortho-suv.org

9. References

1. Bonev I. (2003) The true origins of parallel robots copyright. http://www.parallemic.org/Reviews/Review007p.html. - Accessed on Aug 25, 2005.
2. Dammerer D., Kirschbichler K., Donnan L., Kaufmann G., Krismer M., Biedermann R. Clinical value of the Taylor Spatial Frame: a comparison with the Ilizarov and Orthofix fixators J Child Orthop (2011) 5:343–349.
3. Iwaki H, Pinskerova FMAR (2000) Tibiofemoral movement 1: the shapes and relative movements of the femur and tibia in the unloaded cadaver knee. J. Bone Joint Surg. 82-B:1189–1195
4. Marangoz S., Feldman D.S., Sala D.A., Hyman J.E., Vitale M.G. Femoral deformity correction in children and young adults using Taylor spatial frame. Clin Orthop Relat Res. 2008;466(12):3018–3024.
5. Method of Unified Designation of External Fixation (MUDEF). Available at: http://ortho-suv.org/index.php?option=com_content&view=article&id=127&Itemid=93&lang=en and http://ortho-suv.org. Accessed on October 23, 2012.
6. Paley D. (2005) Principles of deformity correction. Springer, New York
7. Paley D. (2011) History and science behind the six-axis correction external fi xation devices in orthopaedic surgery oper Tech Orthop 21:125–128. Elsevier Inc.
8. Rozbruch S.R. Correction of tibial deformity with use of the Ilizarov-Taylor spatial frame / S.R. Rozbruch, A.T. Fragomen, S.Ilizarov // J. Bone Joint Surg. – 2006. – Vol. 88-A, Suppl. 4. – P. 156–174.
9. Seide K., Wolter D., Kortmann HR (1999) Fracture reduction and deformity correction with the hexapod Ilizarov fixator. Clin Orthop 363:186–195
10. Seide K. (2004) Application of the Hexapod- fixator. Litos, Hamburg
11. Seide K., Gerlach U., Inden Ph., Bohn B., Juergens Ch. (2008) Dimensional corrections with the Hexapod system added to the Ilizarov apparatus. In: 5th meeting of the A.S.A.M.I. international: program and abstract book, St. Petersburg, 2008, pp 83–84
12. Solomin, L.N. The basic principles of external fixation using Ilizarov device / L.N. Solomin // Italy, Milan: Springer-Verlag, 2008. – 357 p. (http://rniito.org/solomin_eng/download/the_basics.pdf)
13. Solomin, L.N. Practical Classification of long bone deformities / L.N. Solomin, V.A. Vilensky // 5th Meeting of the ASAMI International. Program and Abstract Book. – St.Petersburg, 2008. – P. 339. (http://rniito.org/solomin_eng/deform_class.jpg)
14. Solomin L.N., Terrell W., Odessky J. (2008) Multifactorial comparative analysis of Ilizarov apparatus and external fixation devices on the base of computer navigation (Taylor Spatial Frame, Ilizarov Hexapod Apparatus, SUV-Frame). In: 5th meeting of the ASAMI international. Program and abstract book. St. Petersburg, 2008, p 52
15. Solomin, L.N. Comparative analysis of reduction capabilities provided by software based external fixation devices and Ilizarov apparatus / L.N. Solomin, V.A. Vilensky, A.I. Utekhin, W. Terrell // The Genius of Orthopedics. – Kurgan, 2009. - # 1 – 5-10 p.p.
16. Solomin, L.N. Comparative analysis of reduction capabilities provided by software based external fixation devices and Ilizarov apparatus / L.N. Solomin, V.A. Vilensky,

A.I. Utekhin, W. Terrell // The Genius of Orthopedics. – Kurgan, 2009. - # 1 – 5-10 p.p.

17. Solomin, L.N. Comparative analysis of rigidity fixation provided by software based external fixation devices and Ilizarov apparatus / L.N. Solomin, V.A. Vilensky, A.I. Utekhin, W. Terrell // Traumatology and Orthopedy of Russia. – St.-Petersburg, 2009. - # 2. – 20-25 p.p.
18. Solomin L. (2013) The basic principles of external skeletal fixation using the Ilizarov and other devices. Springer, Milan
19. Solomin L., Vilensky V., Utekhin A. Deformity Correction and Fracture Treatment by Software-based Ortho-SUV Frame: User Manual. Available at: http://ortho-suv.org. Accessed on March 12, 2013.
20. Taylor J.C. (1997) A new look at deformity correction. Distraction. The Newsletter of ASAMI-North America 5(1)

Appendix 1

Steps to be followed before you start using the Ortho-SUV Frame Software

Step No. 1
Create a folder named Ortho-SUV on your Laptop / Desktop, on which you want to run the program.

Step No. 2
Insert the Ortho-SUV Frame Software CD supplied to you in the disk drive of your Laptop / Desktop. Copy the folder SUV-Software on the software CD into the Ortho-SUV Folder created by you.

Step No. 3
Click on the “Hasp” folder, then click on the folder “Sentinel_LDK_Run-time_setup-2011” & click again on “HaspUserSetup.exe” file. Install the Hasp program following the steps as prompted.

Step No. 4
Before working in the program it’s necessary to create the folder for the clinical case. In this folder AP and lateral x-ray images of the patients in (jpeg) or (.bmp)format should be placed. In the same folder the file made later by Ortho-SUV program for the subject case should be also saved.

Step No. 5
Attach the Hasp key to the USB drive of your laptop & then double-click “SUV-Software.exe” file. Program window will appear. Press the "New document" button. Save your case folder allocating a file name to it & then follow the steps as prompted by the software.

Note 1: Immediately after the new document (that is, “clinical case”) has been created, it is necessary to save it (command “Save” in “File” menu) in the patient case folder. It is recommendable to repeat saving after every step.

Note 2: The software will not work without the Hasp Key. Hence, ensure that the Hasp key is kept safely.