Complications and Solutions

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Leonid Nikolaevich Solomin and Stuart Alan Green

External fixation devices are more complicated than internal fixation implants. Consequently, external fixation has more nuances than other methods of osteosynthesis and the surgeon must be aware of possible complications and how to avoid or at least limit them.

The enormous variation in the percentage of complications reported in the literature for external fixation (1.5–100%) has given rise to endless debates. The complications can be divided into those occurring during the operation and those inherent to the postoperative period, both during the fixation period and after disassembly of the device. In some cases, different complications can lead to the same unfavorable result (Figs. 33.1, 33.2, 33.3, 33.4, 33.5, 33.6, 33.7, 33.8, and 33.9).

According to the SOFCOT classification [706], patients with complications can be divided into three categories:

Category 1: No complications at all or mild complications not detected during the treatment period

Category 2: Complications requiring surgical interventions not planned at the beginning of treatment but which can be eliminated without consequences or with consequences not worsening the treatment result

Category 3: Serious complications with consequences at the end of treatment and/or deterioration of the treatment result

Table 33.1 lists some of the complications, the causes of their development, the principles of prophylaxis, and the recommended treatment.

If conservative treatment of pin-tract infection (Fig. 33.1) for 3–4 days is ineffective, the transosseous element should be removed. In the presence of concomitant diabetes, more active tactics are needed: wide opening of the wire channel, drainage, antiseptic dressings, and treatment with antibiotics (with due regard for sensitivity), enzymatic drugs, or a solution of insulin and glucose. According to indications, dressings with a water-soluble ointment are placed on the wound. Optimum insulin therapy is supplemented with the use of albumin drugs, anabolic hormones, angioprotectors and immunostimulants [491]. Special attention should also be paid to wires inserted near growth zones. Stabilizing the frame by the insertion of additional wires (or half-pins) may be necessary.

Delayed removal of a septic wire can lead to pin-tract osteomyelitis (Fig. 33.2), which is also caused by burning the bone during insertion of a wire or pin, especially if a dull drill bit was used. Usually, the course of pin-tract osteomyelitis is not malignant, and spontaneous remission is often the case. However, resistant osteomyelitis requires operative treatment, with excision of the ring sequestrum and debridement of the pin or wire hole.

Inflammation of the soft tissues near transosseous elements inserted near joints can result in septic arthritis. In such cases, the injured joint is stabilized by mounting on an additional transosseous module followed by removal of the wires or pins inserted through the intrasynovial portion of the joint. Septic arthritis is treated by the usual method with due regard to the specifics of the disease.

When a nerve is damaged by a wire or pin or there is neuritis caused by the pressure exerted by an adjacent transosseous element, the transosseous implant should be removed. In most cases, conservative treatment is adequate to resolve this complication.

There are also reports of biologically active reactions to the wires, with symptoms, of dermatitis, edema, intermittent fever, and pain, none of which could be eliminated by conservative treatment [80, 85, 103, 707]. Removal or replacement of 1–2 wires may be necessary if local treatment fails to control the problem. A reflex therapist should be consulted, if needed.

Soft-tissue cutting (Fig. 33.5) by the wires is common during distraction and cross-wire bone transport. It is

L.N. Solomin, M.D., Ph.D. (✉)
R.R. Vreden Russian Research Institute of Traumatology and Orthopedics, 8 Baykova Str., St. Petersburg 195427, Russia
e-mail: solomin.leonid@gmail.com

S.A. Green, M.D.
Department of Orthopedic Surgery, University of California, Irvine, 3771 Katella Avenue Suite 310, Los Alamitos, CA 90720, USA

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Fig. 33.1 Principal causes of infectious complications. (**a**) Failure to observe the rules regarding asepsis and antiseptics: pay attention to possible soiling of the device's frame and of the disc clips holding the gauze pads. (**b**, **c**) Chronic trauma (in this case, tension) to the soft tissues by the transosseous elements. (**d**) A device assembly was used that did not provide adequate rigidity for osteosynthesis

Fig. 33.2 (**a**, **b**) Pin-tract osteomyelitis

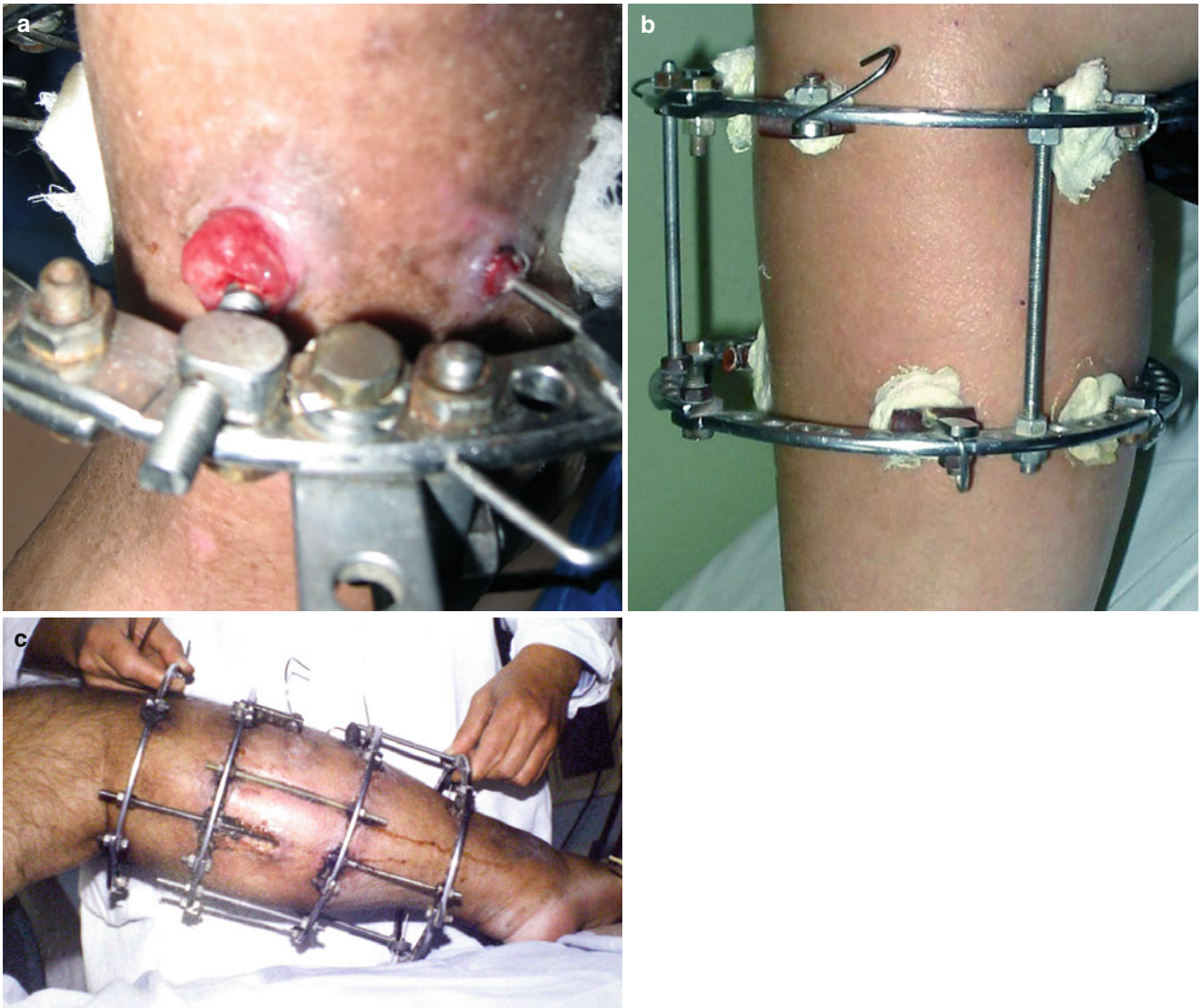

Fig. 33.3 In this case, soft-tissue necrosis has arisen owing to excessive pressure upon the skin of a disc clip used to hold the gauze pad (**a**). Proximal ring press soft tissues and prevent flexion in knee joint; this will require partial reassembly of the frame (**b**). Incorrect choice of ring diameter and absence of timely care, resulting in complications (observation of I.A. Voronkevich) (**c**)

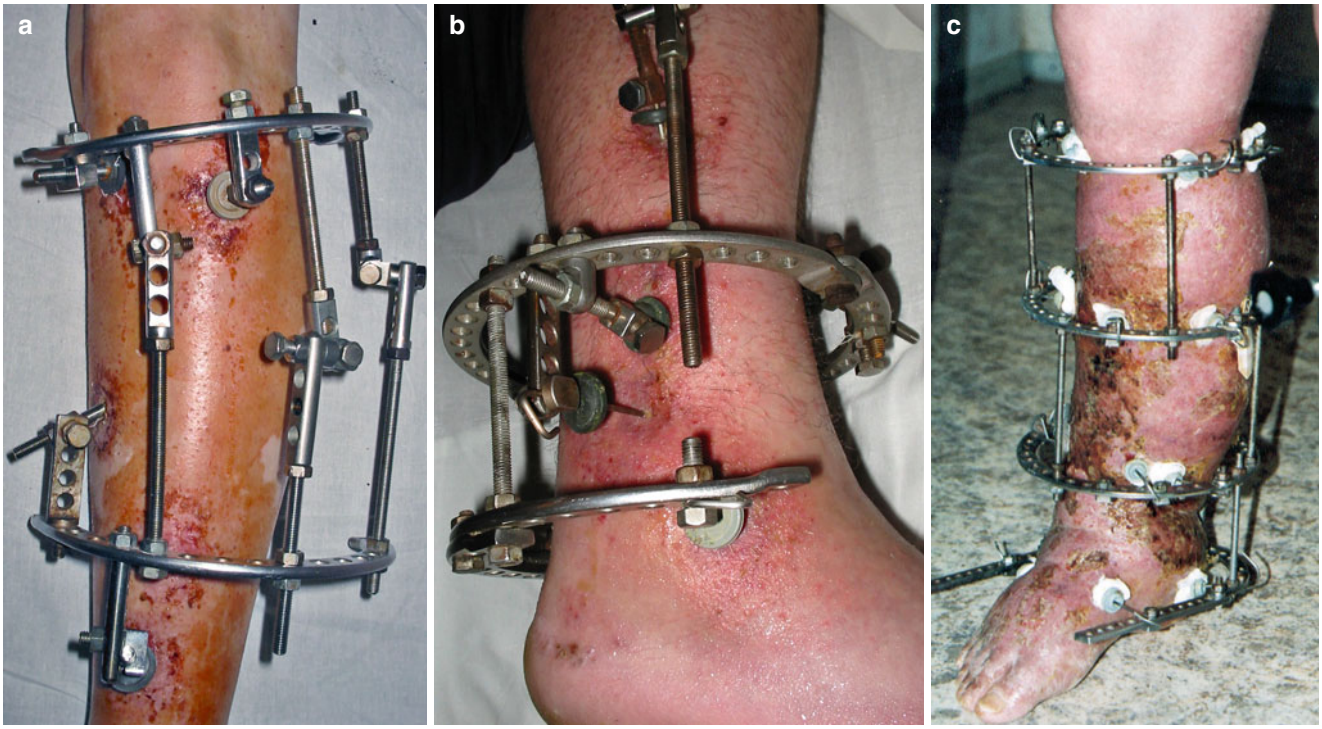

Fig. 33.4 Contact allergic dermatitis (**a**, **b**) in the absence of adequate treatment leads to eczema (**c**). The etiology and pathogenesis of traumatic eczema, except for infectious process, has been ascribed by some authors to autosensitization to the allergen, in this case wires inserted through acupunctural points

Fig. 33.5 If pressure of a wire upon the soft tissues is relieved in due time, it does not lead to significant consequences (**a**). Removal of a half-pin in this case will lead to wound healing within 2 weeks (**b**). Soft-tissue cutting by transosseous elements results in infectious complications, with non-healing wounds (**c**, **d**). Distraction between transosseous elements entered into projections of the same position at different levels (for example, III, 9 and V, 9) can lead to the occurrence of necrosis tracks connecting these elements. Therefore, the greater the distraction, the greater the distance should be between wires and half-pins of different transosseous modules ("a stock of soft tissues"). Except for rare cases, it is necessary to avoid introducing transosseous elements in a longitudinal alignment (**e**)

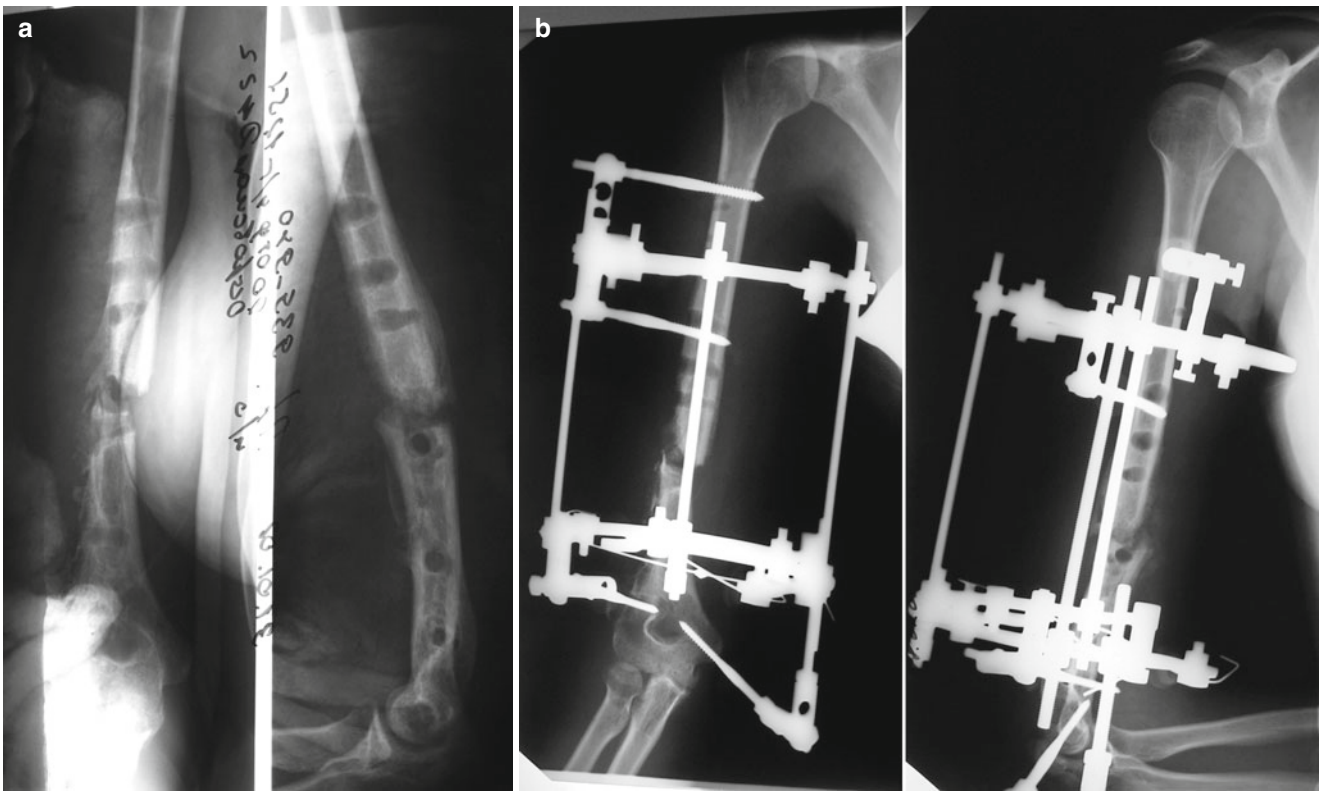

Fig. 33.6 Treatment of a patient with a non-union of the humerus and pin-hole fracture. (**a**) Roentgenogram before treatment; (**b**, **c**) combined external fixation and upper limb function on postoperative day 4. (**d**) A fall from a height of 2 m resulted in a crisis in the field of half-pin IV,9,90: (**e**) reassembly of the device; (**f**) modular transformation of the frame; (**g**) 5.5 months later. After a primary osteosynthesis, the device was dismantled; (**h**) upper limb function 3 days later

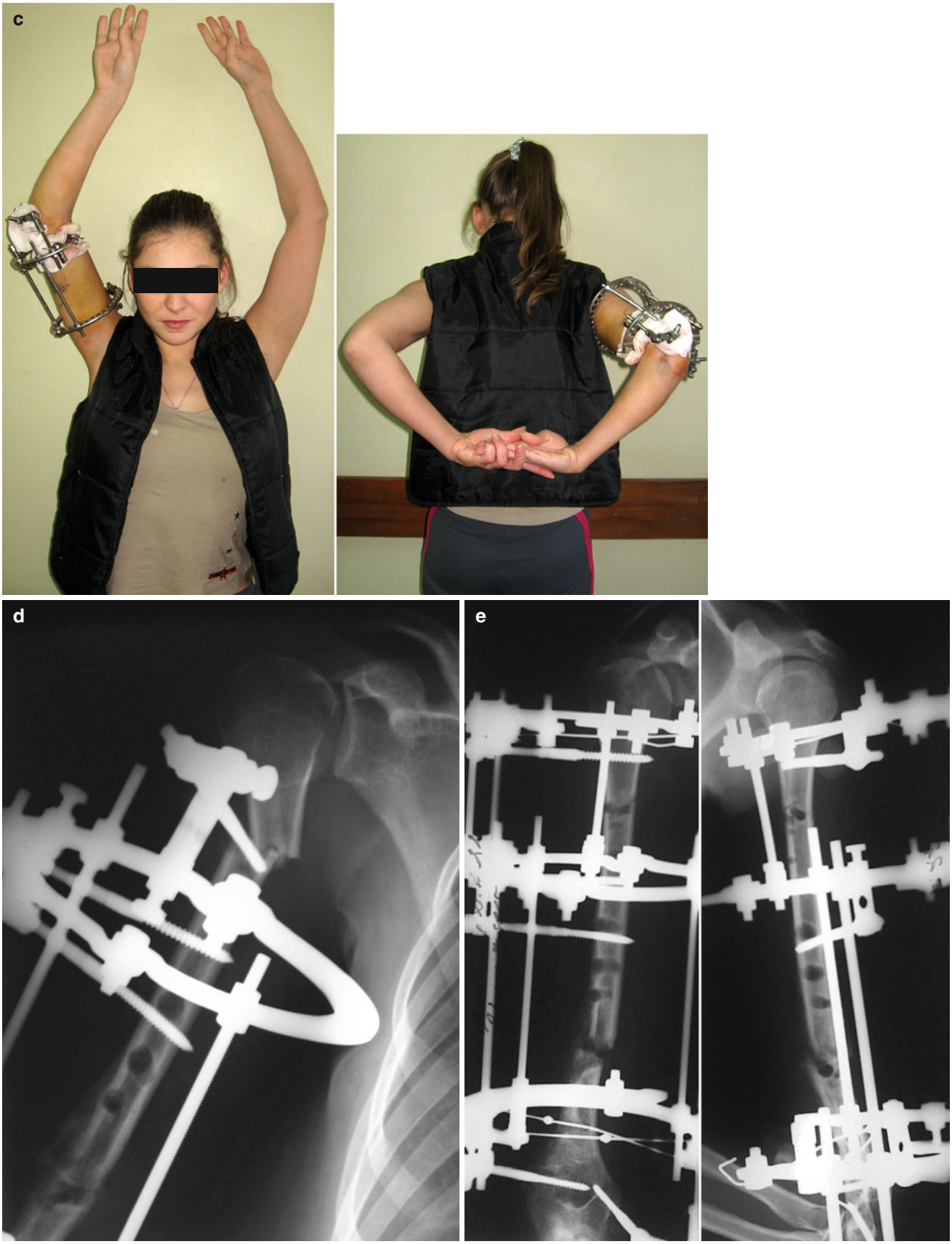

Fig. 33.6 (continued)

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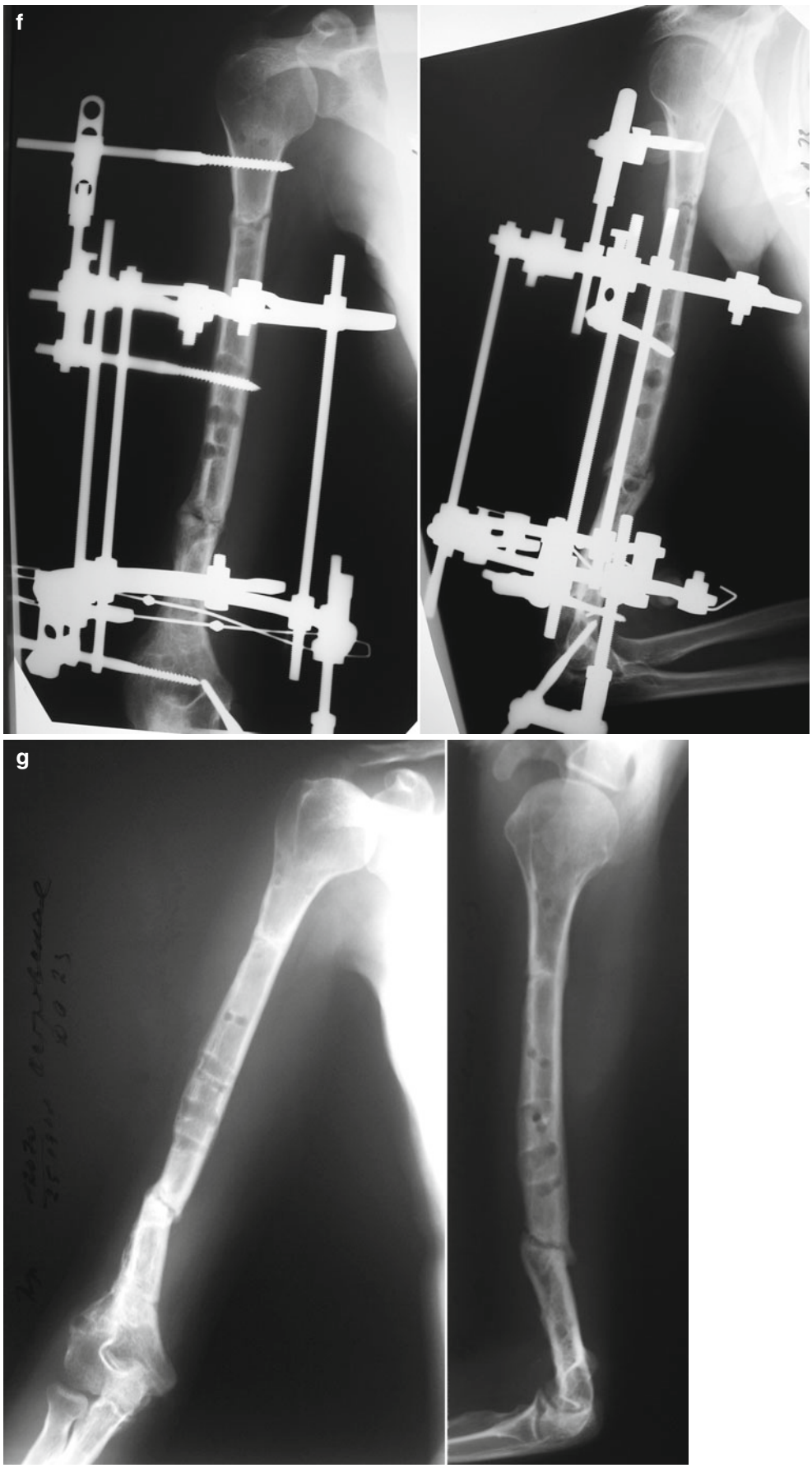

Fig. 33.6 (continued)

Fig. 33.7 (**a–d**) A principal cause for the development of pin-induced joint stiffness is the failure to use reference positions (Chap. 5) in the introduction of transosseous elements (**a**, **b** and **d**) as well as a "superfluous" amount of wires and pins (**c**)

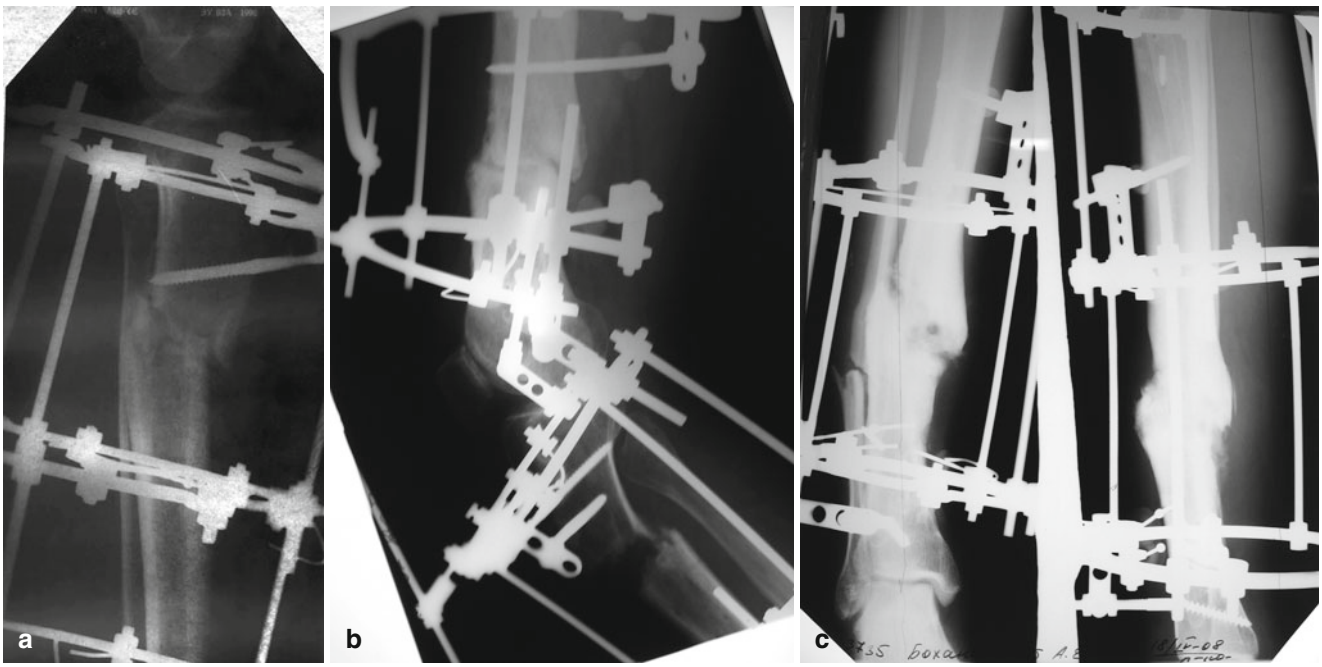

Fig. 33.8 Secondary bone fragment displacement, as a rule, reflects the absence of coaxiality between the transosseous modules and the axes of the bone fragments (**a**), an inadequate rigidity of bone fragment fixation with respect to the applied loading (**b**), the breakage of transosseous elements (**c**), or problems with details of the frame's configuration

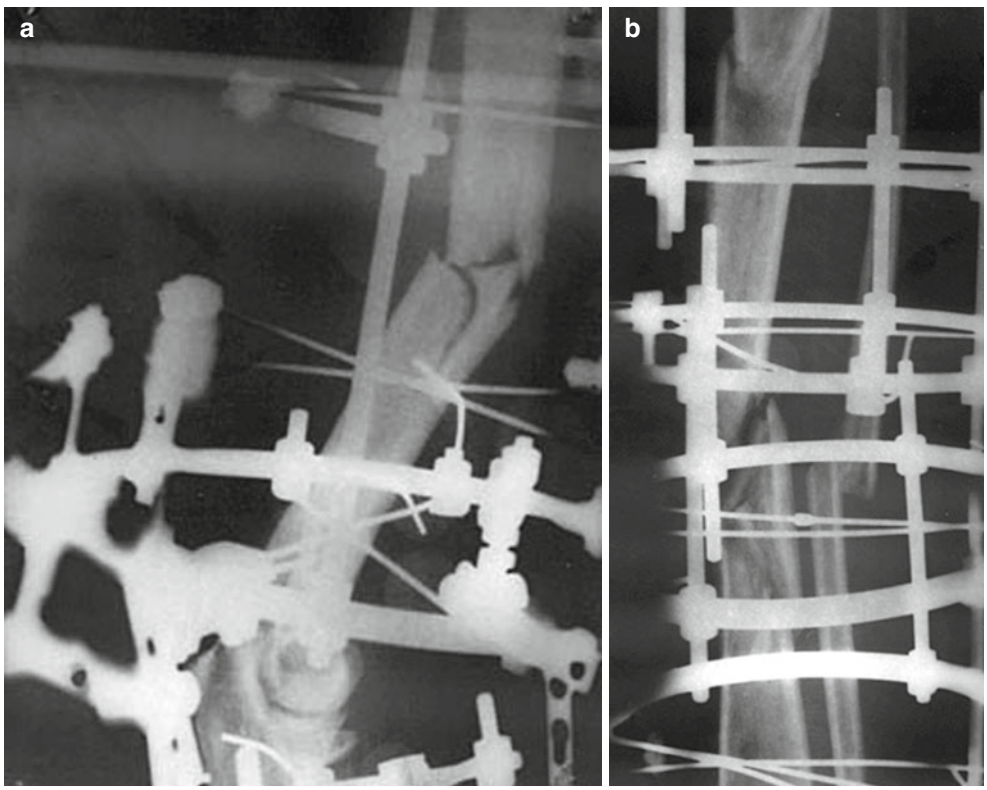

Fig. 33.9 (**a–d**) The method of external fixation is invalidated by incorrect configurations of the devices and the absence of bone fragment reduction, in turn leading to malunion and non-union

Fig. 33.9 (continued)

Table 33.1 Complications of external fixation

Complications	Main causes	Prophylaxis	Treatment
Inflammation of the soft tissues around transosseous elements (pin-tract infection)	1. Violation of asepsis and antiseptics rules	1. Strict observance of asepsis and antisepsis during the insertion of transosseous elements; use of dressings	Administration of antibiotics with due regard for the sensitivity of the microflora
	2. Chronic trauma of soft tissues adjacent to transosseous elements	2. Use of positions with minimum soft-tissue displacement during the insertion of transosseous elements, thus eliminating tension on the soft tissues	Releasing soft tissues to eliminate tension by transosseous elements
	3. Instability of the external device	3. Measures to maintain the construction stability	Restoration of device stability
Soft-tissue necrosis (caused by pressure of the external supports and other device elements)	1. Use of external supports of inadequate size	1. Arrangement of the device supports with due regard for the possibility of increasing the ring circumference by 4–6 cm; eccentric arrangement of the supports with room for the soft tissues at potential sites of swelling	As an urgent measure, when there is a danger of compression: placement of a flexible flat spacer between the ring and the skin; elevated position of the extremity
	2. Excessive pressure exerted by the wires	2. When there is a danger of pronounced swelling, decreased compression of the gauze pads surrounding the wires	Partial reinstallation of the device Debridement (if necessary), local treatment of the pathological process
Injury of vessels and nerves	1. Insertion of transosseous elements with knowledge of vessel and nerve anatomy	1. Use of "safe" and "reference" positions for the insertion of wires and half-pins; use of preliminary contrast vascular studies in difficult cases; half-pin insertion with vessels and nerves beyond the opposite cortex	Removal of the transosseous element and hemostasis by compression of the soft tissues or ligature of the vessel (if necessary)
	2. Winding of soft tissues on the wire	2. Use of wires with polished surfaces; use of a pin or wire drill sleeve	In case of bleeding caused by decubitus, operative treatment (ligature, vascular, plasty)
Dermatitis	1. Dressings with drugs causing allergic reactions	1. Allergen elimination	Allergen elimination
	2. Reaction to the presence of an infected wound, soft-tissue inflammation in the region of the transosseous elements (microbial eczema)	2. Timely diagnosis and treatment of the inflammatory process	Stopping the inflammatory process Consultation with a dermatologist
Neurovascular disorders	In most cases, exceeding the distraction or compression rate	Controlled rate of distraction of the bone fragments	Increase distraction multiplicity (e.g., from 0.25×4 to 0.125×8)
		Use of automated high-frequency, low-increment distractors	Decreased distraction rate or temporary interruption or reversal of distraction Pharmacotherapy, physiotherapy

Contractures and pin-induced joint stiffness	1. Insertion of the transosseous elements at sites where soft-tissue displacement is large relative to the bone	1. Use of "reference positions" for wire and half-pin insertion	Intensive exercise therapy
	2. Failure to account for soft-tissue displacement during wire insertion	2. Creation of redundant soft tissues by proper positioning when inserting transosseous elements through "flexion" and "extension" surfaces of the limb; manual displacement of soft tissues	Use of special components in the device to increase of ROM
	3. Use of rings that are too close to the joints	3. Use of open external supports (half-rings, 2/3 rings) near joints	Replacement or removal of transosseous elements
	4. Tension of the soft tissues because of distraction	4. To prevent permanent contractures, avoidance of segment lengthening in a single stage by more than a certain critical magnitude	Reducing the rate of lengthening, or stopping altogether
	5. Disregarding additional measures for contractures prophylaxis	5. Use of special positions of the extremity after the operation, as well as devices attached to the apparatus Active-aggressive postoperative rehabilitation; maintenance during the entire fixation period of the joint movement amplitude present on the operating table instead of trying to regain ROM after contracture appearance	
Subluxations and dislocations of the joints	1. Violation of lengthening principles (including excessive magnitude of lengthening, too rapid rate of distraction); errors in apparatus arrangement	1. Strict observance of osteosynthesis methods	Stopping the distraction
	2. Disregarding the prophylaxis of this complication	2. Taking preventive measures (e.g. temporary fixation of the joint with a transosseous hinge module)	Modification of the device (if necessary) Mounting of additional components to allow correction of the present complication Arthrolysis, lengthening the tendons (according to indications)
Secondary bone fragment displacement	1. Failure to observe the biomechanical fundamentals of mounting, reduction, and fixation of bone fragments	1. Strict observance of biomechanical standards when using external fixation	As a rule, partial reinstallation of the external device
	2. Failure of device components	2. Use of high-quality certified equipment	
	3. ROM, segment condition, and frame uncontrolled	3. Adequate patient monitoring	
Breakage of transosseous elements, failure of device components	1. Overloading of the "frame – extremity" system	1. Proper device mounting (including wire tension); ensuring that: (a) loads on the extremity correspond to the bearing capability of the newly formed bone; (b) the rigidity of bone fragment fixation by use of an adequate device assembly	Replacement of broken components; partial reinstallation of the device
	2. Defective metalwork or metal fatigue	2. Use of high-quality certified equipment	
	3. Lack of observance of the rules for storage, sterilization and disinfection of the device, resulting incorrosion; deformity, loss of mechanical properties due to temperature changes, etc.	3. Observance of the rules for storage, sterilization, and disinfection of the device	

(continued)

Table 33.1 (continued)

Complications	Main causes	Prophylaxis	Treatment
Cutting into the bone by the transosseous elements	1. Insertion of transosseous elements near the cortical edge 2. Inadequate area of the wire's bead (stop) in relation to the requirements of the fixation and the magnitude of osteoporosis 3. Use of half-pins in patients with pronounced osteoporosis	1. Insertion of the transosseous elements through two cortices, except in special cases 2. Increased number of transosseous elements and use of a beaded wire of adequate area 3. Use only of beaded wires in case of pronounced osteoporosis	Replacement of transosseous elements when necessary to retain their initial number and the degree of bone fragment fixation rigidity
Patient's psychological inability to accept external fixation	Underestimation of the patient's psychological condition before treatment and of critical circumstances in the patient's life that make the further use external fixation devices impossible	Taking into consideration all contraindications for the use of external fixation	Consultation with a psychotherapist Sedative therapy Removal of the device only when absolute necessity and conversion to other methods of fixation
Malunion, non-union and formation of a hypoplastic distraction regenerate	1. Inaccurate reduction of bone fragments; secondary displacements 2. Inability of the frame to provide early restoration of ROM and weight-bearing	1. Ensuring accurate reduction (adaptation in reconstructive procedures); prophylaxis of secondary displacements 2. Use of an external fixation device that achieves rigid fixation, adequate to weight-bearing capability of the regenerate bone and early ROM	Gradual bone fragment reduction Ensuring adequate rigidity of fixation Use of special methods for optimizing reparative osteogenesis on the basis of biological, mechanical, physical and pharmacological factors
Post-fixator re-fracture, secondary deformity	1. Premature removal of the device, inadequate loading after dismantling the device (including due to non-observance of recommendations by the patient) 2. Bone union without restoration of the mechanical extremity axis 3. Union involving a limited cross-sectional area 4. Primary union (without periosteal callus)	1. Consideration of clinical, X-ray criteria for device dismantling 2. Restoration of the mechanical axis 3. Exact reduction of the fragments 4. Subsequent decrease in weight-bearing after device removal	Conservative treatment, re-osteosynthesis, reconstructive surgery(according to indications)

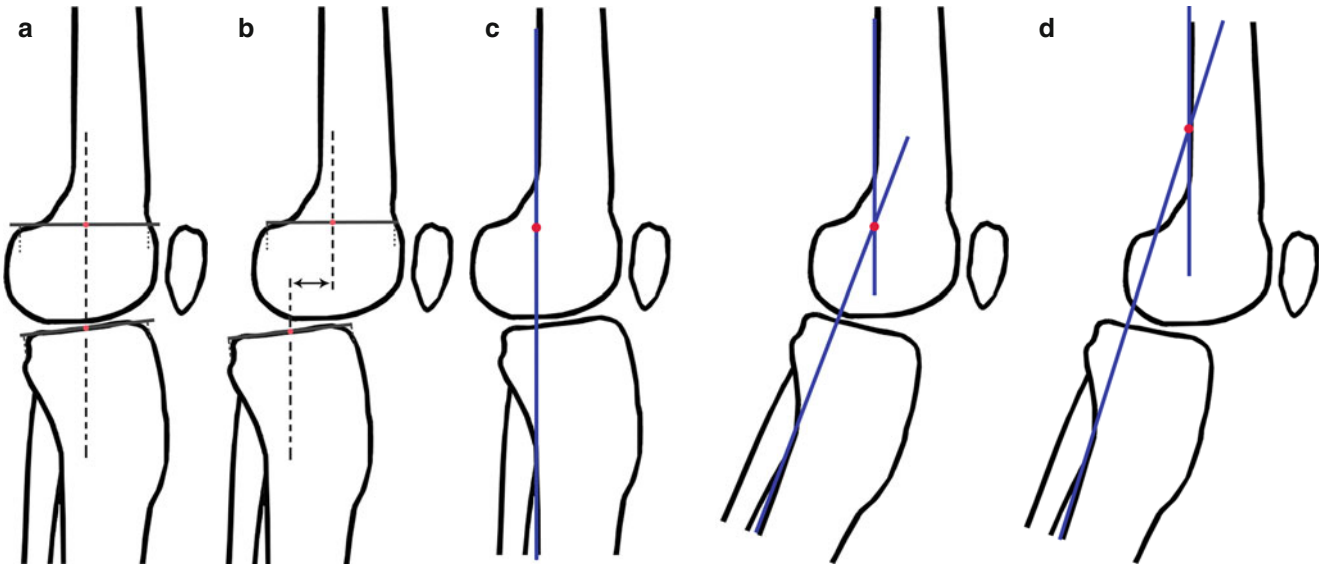

Fig. 33.10 (**a–d**) Identification of knee joint subluxation in sagittal plane. (**a**) At knee joint extension the centers of joint lines should correspond to each other. (**b**) Subluxation in the knee joint. (**c**) The axis of rotation of the knee in sagittal plane is located in crossing of posterior cortical lines of femur and tibia (at knee extension these lines coincide). In order to find the axis of rotation of a knee joint, it is necessary to make the roentgenogram of contralateral (intact) joint. (**d**) Flexion contracture and subluxation

generally cured in two stages. In a distraction of up to 4–6 cm (depending on the segment), releasing the soft tissues is often sufficient. Later, reinsertion of the transosseous elements is required. The use of oblique-wire bone transport or an axial distraction wire will reduce the likelihood of this complication. In case of soft-tissue damage caused by joint movement, the skin should be cut as necessary.

The diameter of a half-pin must not exceed 20% of the bone diameter at the level of its placement so as not to decrease the mechanical strength of the bone [708]. In case of pin-hole fracture (Fig. 33.6), reassembly of the device or, rarely, changing the fixation method may be necessary.

To prevent the development of resistant joint contractures, the segment should not be lengthened in one stage and should not exceed a certain critical value, which is determined individually with due regard to the segment being lengthened, the type of pathology, and the method used. In particular, lengthening by >15% of the initial segment should not be attempted if before treatment there was moderate limitation in the range of motion of the adjacent joints. A decrease in the range of motion by an average of 50–60% of the initial value is the limit. It should be kept in mind that the closer to the joint the transosseous elements are inserted or the closer to the joint the corticotomy is performed, the greater is the risk of contracture development. In case of bilocal lengthening of the lower leg, after the formation of a distal distraction regenerate of more than 20–30 mm there appears to be an increased risk of pes equinus, even when all precautionary measures are taken. This is an indication that the rate of distraction should be reduced to 0.25 mm once or twice a day, or even stopped. Residual shortening should be compensated by the formation of the proximal distraction regenerate.

Knee joint flexion contracture at femur lengthening is quite often accompanied by posterior subluxation of tibia. In Fig. 33.10 is shown how it is possible to find subluxation in knee joint in sagittal plane.

The treatment of already-generated joint stiffness and/or subluxation is described in Chap. 23.

The main way to prevent complications of external fixation was enunciated by G.A. Ilizarov: “A surgeon should know not only the device but also the method proposed with it; therefore, its detailed mastering is a must.” Careful following of this advice will allow most complications to be avoided.