SYSTEMATIC REVIEW

Acute Shortening for Open Tibial Fractures with Bone and Soft Tissue Defects: Systematic Review of Literature

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Abstract

Introduction: The presence of massive soft tissue loss in open tibial fractures is a challenging problem. Acute limb shortening is an alternative solution in situations where the use of flaps is limited.

Materials and methods: A review was conducted following the Preferred Reported Items for Systematic Reviews and Meta-analyses checklist (PRISMA) guidelines. A complete search of PubMed, EMBASE and MEDLINE was undertaken. Twenty-four articles related to closure of soft tissue defects through acute limb shortening were identified and included in this review.

Results: All report on restoration of limb function without or with minimal residual shortening. The authors note a decrease in the need for microsurgery. The external fixation devices used for deformity correction after closure of the soft tissue defect by acute shortening, angulation and rotation were the Ilizarov apparatus and circular fixator hexapods mainly.

Conclusion: Acute shortening is an alternative to microsurgical techniques. A ring external fixator is useful for restoring limb alignment after closing the soft tissue defect through creating a temporary deformity. The use of circular fixator hexapods can enable accurate correction of complex multicomponent deformities without the need to reassembly of individual correction units.

Keywords: Acute shortening, Angulation and rotation, External fixation, Ilizarov method, Open fracture, Soft tissue defect closure.

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Introduction

A large number (up to 24%) of tibial fractures are open injuries.[1,2] A significant proportion of open fractures are associated with extensive soft tissue damage (Gustilo-Anderson type IIIB).[3,4]

It is recommended that definitive soft tissue closure or coverage should be achieved within 72 hours of injury if it cannot be performed at the time of debridement.[5–7] The use of soft tissue flaps is the most common method[8] but there are situations when this strategy is not feasible. These include the inadvisability of prolonged surgical procedures in patients with polytrauma, or in patients who retain only a single vessel in the limb where the reconstruction undertaking is more complex. Massive damage to local soft tissues as well as an uncertain demarcation of the zone of the damage complicate matters further. Diabetes mellitus, immunodeficiency, malnutrition or a high degree of obesity are cautionary factors for the use of. One of the commonest reasons for not using flaps is the lack of a qualified plastic surgeon.[9–14]

An alternative solution in such situations is the method of acute limb shortening.[9,15–18] The subsequent restoration of the length, alignment and shape of the limb is based on the principles of distraction histogenesis by Ilizarov; this was predicated on the general biological property of tissues responding to the dosed tension-stresses applied for growth and regeneration.[19–21]

The purpose of this study was to review the published literature on the acute shortening method for the treatment of open fractures associated with extensive soft tissue defects (Flowchart 1).

Materials and Methods

This literature review was carried out with guidance from the Preferred Reported Items for Systematic Reviews and Meta-analyses checklist (PRISMA).

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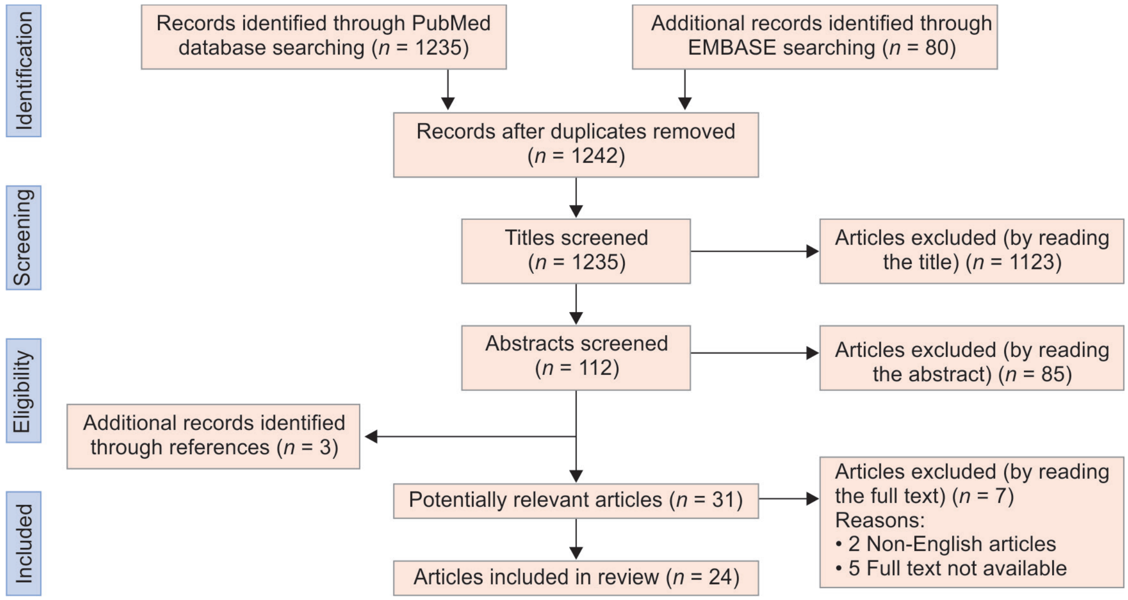
Search Strategy

PubMed, EMBASE and MEDLINE databases for the period from 1991 to 2021 were used.

The following search string was used in the PubMED database: "[acute shortening (Title/Abstract) AND soft tissue (Title/Abstract)] OR soft tissue defect (Title/Abstract) OR primary shortening (Title/Abstract) OR [soft tissue loss (Title/abstract) AND distraction (Title/Abstract)] OR [soft tissue defect (Title/Abstract) AND Ilizarov method (Title/Abstract)] OR [shortening (Title/Abstract) AND angulation (Title/Abstract) AND soft tissue coverage (Title/Abstract)] OR acute deformation (Title/Abstract) OR acute deformity (Title/Abstract) OR (open fracture (Title/Abstract) AND soft tissue defect (Title/Abstract)] OR [external fixation (Title/Abstract) AND soft tissue

Flowchart 1: The search process for identifying literature included in the review



defect (Title/Abstract)]". A total of 1236 articles were found and 24 articles were included after consideration of the eligibility criteria.

Eligibility Criteria

Articles published in English in peer-reviewed journals and monographs; original articles, systematic reviews, and meta-analyses were included in this literature review.

Special attention was paid to:

- The method of acute shortening, angulation and rotation and the consequences thereof in the treatment of open fractures accompanied by extensive soft tissue defects.
- Principles and techniques for closing soft tissue defects relevant to the depth and area of the damage through using the acute shortening method.
- Correction of the deformity formed after the closure of the soft tissue defect.

Results

The suitable articles were divided into two groups.

The first group—the use of the acute shortening method in acute trauma (Group I—Table 1).

The second group—the use of the acute shortening method for consequences of trauma such as infection (Group II—Table 2).

Acute shortening was used by six authors for acute trauma (Table 1:1, 2, 7, 11, 16, 17). Two authors used both acute shortening and a combination of acute and gradual shortening (Table 1:4, 8). Acute shortening and angulation were used by six authors (Table 1: 5, 6, 9, 12, 13, 15). The combination of acute shortening, angulation and rotation is mentioned by two authors (Table 1:6, 18).

Two authors (Table 2:6, 8) used acute shortening for cases which were consequent to complications of trauma. Another two authors used both acute shortening and a combination of acute and gradual shortening (Table 2:3, 4). Acute shortening and angulation were used by four authors (Table 2:1, 2, 7, 9).

In acute trauma, 11 authors used the Ilizarov apparatus to correct the created deformity (lengthening or elimination of angulation or both) (Table 1:1, 2, 4, 5, 6, 7, 8, 10, 15, 16, 17). The hexapod Taylor Spatial Frame was used by four authors (Table 1:12, 13, 14, 18). Three authors performed correction using various types of monolateral external fixation devices (Table 1:7, 8, 11).

For cases which were consequent to complications of trauma, the Ilizarov apparatus was used by six authors (Table 2:1, 3, 4, 5, 6, 8). Four authors used a Taylor Spatial Frame (Table 2:2, 3, 7, 9). Monolateral external fixation devices for deformity correction were used by two authors (Table 2:4, 6).

The maximum acute shortening carried out in a single stage was 3 cm by four authors. Further shortening was carried out gradually.[15,22–24] One author has stated that the limit of acute shortening is determined by the state of the soft tissues and the vascular status of the injured limb.[25] Other authors have proposed to control the safety of acute shortening by using intraoperative Doppler sonography and by monitoring blood flow in the distal vessels (*a. dorsalis pedis* and *a. tibialis posterior*), or with pulse oximetry on the big toe.[26,27]

The size of the soft tissue defect closed by the methods of acute shortening, angulation, rotation singly or in combination varies greatly. In acute trauma, this was found to be from 1 × 2 cm (Table 1:4) to 12 × 20 cm (Table 1:6). For cases which were consequent to complications of trauma, the defect was from 2.5 × 2.5 cm (Table 2:2) to 10 × 15 cm (Table 2:1, 5).

The size of the bone defect ranged from 1 cm (Table 1:17) to 22 cm (Table 1:6) in the acute injury group and from 1 cm (Table 2:8) to 14 cm (Table 2:3) in the group of trauma consequences. The total fixation time in the device (inclusive of primary fixation, deformity correction and consolidation) in acute trauma ranged from 2 to 3 months (Table 1:4, 5) to 53 months (Table 1:5). For those cases that were complications of trauma, this ranged from 3 months (Table 2:8) to 16 months (Table 2:6). In both groups, the authors noted a decrease in the need for microsurgical intervention, namely, free flaps when using the acute shortening method to close extensive soft tissue defects. However, quantitative indicators are not provided.

All authors write of "complete or almost complete restoration of limb function with minimal shortening". Some (Table 1:3, 4, 10, 18;

Table 1: Group I using the acute shortening method in acute trauma

	Authors, publication date	*Number of patients*	*Aetiology of the soft tissue defect*	*Defect closure method (shortening, angulation, rotation, combined)*	*Area of the soft tissue defect*	*Deformity correction method*	*The need for microsurgical intervention*	*Time of fixation in the ExFix*	*Size of the bone defect*	*Restoration of anatomy and function of the limb*	*Complications*
1	Giebel, 1991	10	Open fractures	Acute shortening	No data	Lengthening with the Ilizarov apparatus	No data	No data	No data	Complete restoration of the limb length	Observed in 5 patients
2	Betz et al., 1993	7	Full or partial amputation	Acute shortening	No data	Corticotomy at the metaphyseal or submetaphyseal level followed by lengthening with the Ilizarov apparatus	Placement of a vascular and nerve suture with acute shortening	7–16 months	6–10 cm	In all cases, limb function was restored, residual shortening of 1–2 cm in all cases	Secondary skin necrosis—4, lower leg fracture—1, equinus deformity—1
3	Mullen et al., 2004	1	Open fracture type Gustillo IIIB	Gradual shortening (1–2 mm per day)	4.5 × 4 cm	Ipsilateral lengthening of the femur with the Ilizarov apparatus	None	5 months	No data	Anatomy: complete restoration of the length of the limb (due to lengthening of the hip) Function: limited range of motion in the ankle joint (Ext./Flex.—0/30°)	Were not observed
4	Sen et al., 2004	24	Open fractures of Gustillo type IIIA–IIIB	Acute shortening for defects <3 cm, and gradual shortening for defects >3 cm	The medium size—2.5 × 3.5 (1 × 2–10 × 5) cm	Lengthening with the Ilizarov apparatus	None	3–10 months	The mean size—5 (3–8.5) cm	Anatomy: complete consolidation in all cases. Residual shortening—3 Function: excellent—19, good—4, satisfactory—1	Limited range of motion—4, chronic osteomyelitis —1
5	Lerner et al., 2004	12	Open fractures of Gustillo type IIIB	Acute shortening—9 cases, acute shortening and angulation—3 cases	No data	Correction of angulation and/or lengthening with the Ilizarov apparatus	1 free flap 3 local flaps 7 autoderma-plastics	2–53 months	2.5–22 cm	Anatomy: residual shortening—1 Complete consolidation in all cases.	Inflammation in the region of transosseous elements (TE)—5

6	Lerner et al., 2005	1	Open fractures of Gustillo type IIIB	Acute shortening and angulation	12 × 20 cm	Correction of angulation and lengthening with the Ilizarov apparatus	Local flap	371 days	22 cm	Anatomy: complete restoration of the limb length Function: return to the previous activity level	No data
7	Yokoyama et al., 2006	6	Open fractures of Gustillo type IIIB	Acute shortening	No data	4 lengthenings with the apparatus Orthofix LRS, 2 lengthening with Ilizarov apparatus	5 local flaps 1 free flap	224–440 days	The mean size—7.4 (4.5–10.3) cm	Anatomy: full length restoration—2, residual shortening—4. Function: good—3, satisfactory—2, poor—1	Superficial infection—1, deep infection—1, refracture—1, TE break—2, equinovarus deformity—2
8	El-Rosasy, 2007	21	Open fracture of Gustillo type IIIA/B—10, infected nonunion—11	Acute shortening to safe limits and subsequent gradual shortening of 2–3 mm per day	No data	Lengthening with the Ilizarov apparatus for the defects >5 cm lengthening by orthofix apparatus for the defects <5 cm	Autoderma-plastic —2 Rotated flap—1	3.5–11.6 months	The mean size—4.7 (3–11) cm	Anatomy: complete restoration of limb length—13, residual shortening—8	Refracture—1 Temporary paralysis of the peroneal nerve—1 Equinus contracture—1 Inflammation in the area of TE—5 Flexion contracture of the knee joint—3
9	Hsu and Beltran, 2009	5 (6)	High energy military trauma, Gustillo IIIB—4, Gustillo IIIC—2	Acute shortening —4 Acute shortening and angulation—2	No data	Fixation only with the Hoffman II apparatus. Correction of deformities in a military hospital conditions was not performed.	Autoderma-plastic Vascular suture—2	No data	No data	All wounds healed without any signs of infection	No data

(Contd...)

Table 1: *(Contd...)*

	Authors, publication date	*Number of patients*	*Aetiology of the soft tissue defect*	*Defect closure method (shortening, angulation, rotation, combined)*	*Area of the soft tissue defect*	*Deformity correction method*	*The need for microsurgical intervention*	*Time of fixation in the ExFix*	*Size of the bone defect*	*Restoration of anatomy and function of the limb*	*Complications*
11	Parmaksizoglu et al., 2010	13	Open fracture of Gustillo type IIIC—8, traumatic amputation—5	Acute shortening	No data	Lengthening with the New Adult Railing System	Free flap—2 Local flap—1 Applying vascular and nerve sutures	No data	No data	Anatomy: complete restoration of limb length Function: functional status Chen grade II	Valgus deformation of the ankle joint—2, equinus deformation—1, infection—1, non-union—3, deformity of the toes—1
12	Beltran et al., 2010	4	High-energy military trauma, Gustillo IIIB	Acute shortening and angulation	No data	Deformity correction by the TSF	Autodermaplastic—1 Local flap—1	8.8–17 months	The mean size—7 (5–8) cm	Anatomy: complete restoration of limb length Function: all patients move without any aids	Inflammation in the TE region—4, subluxation of the tibiofibular syndesmosis—1, scarring of the tendon of the anterior tibial muscle—1
13	Lahoti et al., 2013	7	Open fracture of Gustillo type IIIB—5, infected non-union—2	Acute shortening—1 Angulation—3 Acute shortening and angulation—1 Acute shortening, angulation and rotation—2	3–10 cm	Deformity correction by the TSF	None	6–9.5 months	No data	Anatomy: complete restoration of limb length	Inflammation in the TE region—1
14	Sharma and Nunn, 2013	2	Open fractures of Gustillo type IIIB	Angulation in both cases	First patient: 2 × 2 and 4 × 4 cm Second patient: 8 × 4 cm	Deformity correction by the TSF	None	5–9 months	No data	Anatomy: complete restoration of limb length Function: returned to previous activity level—1, stiffness in the ankle joint—1	Breaking TE—2

15	Pikkel et al., 2014	1	High energy explosive injury, Gustillo IIIB	Acute shortening and angulation	12 cm	Correction of angulation by the Ilizarov apparatus	Autoderma-plastic	No data	7 cm	No data	No data
16	Kovoor et al., 2015	15	Complete or partial amputation	Acute shortening	No data	Lengthening with the Ilizarov apparatus	No data	5–26.5 months	The mean size—6.9 (3–12.5) cm	Anatomy: complete restoration of limb length—10, residual shortening—2 Function: all patients	Amputation—3, inflammation in the TE area, osteomyelitis—1, persistent pain syn-drome—3
17	Salih et al., 2018	31	Open fractures of Gustillo type III	Acute shortening	No data	Lengthening with the Ilizarov apparatus	Autoderma-plastic	12.6–65.4 weeks	The mean size—3.2 (1–8) cm	No data	Refracture—4, residual deformity—2, non-union—1, inflammation in the TE area—8
18	Hernández-Irizarry et al., 2021	19	Open fractures of Gustillo type IIIB or IIIC	Combined in all cases	10.8 ± 6.4 cm × 7.8 ± 6.8 cm	Deformity correction by the orthopaedic hexapod	Autoderma-plastic—1; Local flap—3	157–461 days	>2 cm—14 patients; <2 cm—5 patients	Anatomy: excellent—12, good—5, poor—1, N/A—1. Function: excellent—9, good—8, fair—1, N/A—1	Nonunion—2, infection—1, incisional abscess—1, wound dehiscence—1

Table 2: Group II using the method of acute shortening in the case of consequences of trauma

	Authors, publication date	*Number of patients*	*Aetiology of the soft tissue defect*	*Defect closure method (shortening, angulation, rotation, combined)*	*Area of the soft tissue defect*	*Deformity correction method*	*The need for microsurgical intervention*	*Time of fixation in the ExFix*	*Size of the bone defect*	*Restoration of anatomy and function of the limb*	*Complications*
1	Bundgaard and Christensen, 2000	1	Open fracture of Gustillo type IIIB, subsequent infection	Acute shortening 3 cm and subsequent gradual shortening (1–2 mm per day) with angulation (4° per day)	10 × 15 cm	Correction of the angulation and lengthening with the Ilizarov apparatus	None	357 days	9 cm	Anatomy: complete restoration of limb length Function: limited range of motion in the ankle joint (Ext/Flex—5/15°)	Were not observed
2	Nho et al., 2006	1	Open fracture of Gustillo type IIIA, subsequent infection	Acute shortening and angulation	2.5 × 2.5 cm	Angulation correction and lengthening by the TSF	None	7 months	6 cm	Anatomy: complete restoration of limb length Function: return to previous activity level	No data
3	Rozbruch et al., 2006	25	Infectious consequences of open fractures type Gustillo II—2, Gustillo IIIA—5, Gustillo IIIB—14, Gustillo IIIC—4; flap problem—2	Acute shortening for defects <3 cm, and gradual shortening for defects >3 cm (monofocal, bifocal and trifocal approach)	The mean size—10.1 (2–25) cm	Lengthening with the Ilizarov apparatus—23 Deformity correction with Taylor spatial frame—2	Autoderma-plastic	10–82 weeks	The mean size—6 (2–14) cm	Anatomy: residual deformity—7	Inflammation in the TE area—11
4	El-Rosasy, 2007	21	Open fracture of Gustillo type IIIA/B—10, infected non-union—11	Acute shortening to safe limits and subsequent gradual shortening of 2–3 mm per day	No data	Lengthening with the Ilizarov apparatus for defects >5 cm Lengthening with Orthofix apparatus for defects <5 cm	Autoderma-plastic—2 Rotated flap—1	3.5–11.6 months	The mean size—4.7 (3–11) cm	Anatomy: complete restoration of limb length—13, residual shortening—8	Refracture—1 Temporary paralysis of the peroneal nerve—1 Equinus contracture—1 Inflammation in the TE area—5 Flexion contracture of the knee joint—3

5	Gulsen and Özkan, 2009	3	Open fracture of Gustillo type IIIB—2, infected non-union—1	Gradual shortening and/or angulation	5 × 4 cm, 15 × 10 cm	Correction of the angulation and lengthening the Ilizarov apparatus	None	182–392 days	The mean size—7.5 (4–11) cm	Anatomy: excellent—3, residual shortening—1 Function: excellent—2, satisfactory—1	No data
6	Demir et al., 2009	8	Infected non-union	Acute shortening	No data	Lengthening with monolateral ExFix—7 Ring ExFix—1	None	9.6 (6–16) months	8.6 (6–10) cm	Anatomy: amputation—1, residual shortening—3, full recovery—4 Function: excellent—1, good—6	Inflammation in the TE area—6, delayed consolidation—1, stiffness of the ankle joint—3, equinus contracture—1, destabilization of the apparatus—1, deep infection of TE—1, uncontrolled infection—1
7	Lahoti et al., 2013	7	Open fracture of Gustillo type IIIB—5, infected non-union—2	Acute shortening—1 Angulation—3 Acute shortening and angulation—1 Acute shortening, angulation and rotation—2	3–10 cm	Deformity correction by the TSF	None	6–9.5 months	No data	Anatomy: complete restoration of limb length	Inflammation in the TE area—1
8	Atbasi et al., 2014	17	Infected non-union—16, open fracture—1	Acute shortening	The mean size—7 × 6.8 (3 × 3–10 × 10) cm	Lengthening with the Ilizarov apparatus	No data	3–12 months	1–6 cm	Anatomy: excellent—11, good—3, bad—3 Function: excellent—10, good—4, satisfactory—3	Refracture—1, amputation—1, inflammation in the TE area—2
9	Minoughan et al., 2019	1	Open fracture of Gustillo type II, subsequent infection	Acute shortening and angulation	1 × 3 cm	Deformity correction by the TSF	None	24 weeks	No data	Anatomy: complete restoration of limb length Function: return to the previous activity level	No data

Table 2:3, 4, 5, 6, 8) used the Paley classification (ASAMI) to evaluate the result;[28,29] others (Table 1:2, 11, 16) used Chen criteria.[30] One author (Table 1:7) used the Puno rating scale.[31] Some researchers (Table 2:1, 2) considered return to work as a criterion.

In both groups, the following complications were more common during the treatment:

- Fractures of the transosseous elements and inflammation of soft tissues in the region of transosseous elements ranged from 0 to 100% in the group of acute trauma and from 0 to 75% in the group from consequences of trauma.
- Contractures and deformities in the adjacent joints range from 0 to 33% for acute trauma and from 0 to 50% for the consequences of trauma.
- Refractures ranged from 0 to 31% in the group of acute trauma and from 0 to 6% in the group of consequences of trauma.
- Various infectious complications ranged from 0 to 33% for acute trauma and 0 to 13% in the group of trauma consequences.

Discussion

An analysis of the literature has shown that the use of the acute limb shortening method for closing a soft tissue defect, with subsequent reconstruction of the shape of the limb with an external fixation device, allows for primary wound closure and reduces the need for microsurgical procedures significantly.[9,11–13,16] The review has shown that there are many different terms for the same or similar solution to the problem of closing a soft tissue defect. These include acute shortening, primary shortening, acute deformation, angular shortening, intentional temporary deformation, intentional deformation, intentional temporary shortening and deformation, shortening with angulation and rotation, etc.[9,11,12,14,18,24,26,27,32–34] We propose the above-mentioned terms can be replaced by one term, “Artificial Deformity Creation” or ADCr, which can include techniques of shortening, angulation and rotation either separately or in combination.

There are aspects of this method that warrant further research. An important unresolved issue is the maximum size and shape of a soft tissue defect when effective use of ADCr is possible without the need for supplementary microsurgery in the form of free flaps. No author has stipulated what this should be apart from reporting on the maximum defect closed in their work. As important is the limit of acute shortening, angulation and rotation at which the soft tissue defect is closed in a single stage. Four authors[15,22–24] have suggested, for a one-step acute shortening, a specific value of 3 cm. Three authors[25–27] propose to base the decision on the state of soft tissues and the vascular status of the injured limb, as well as on the results of pulse oximetry and intraoperative Doppler sonography. According to Atbasi et al. and Hernández-Irizarry et al., the criterion for the limit of acute shortening is the beginning of changes in Doppler and pulse oximetry. For postoperative control, digital subtraction angiography was performed on the 7th day, and a computed tomography with angiography 2 years later.[26] The authors describe the ability of the arteries to adapt to the new length of the limb. Variants to this aspect with angulation, rotation or translation have not yet been studied.

The optimal components of the artificially created deformity in terms of type and size so as to match the location, shape and size of the soft tissue defect have not been determined. With the exception that angulation is performed towards the soft tissue defect especially for unilateral defects, none of the authors give specific values. Lahoti et al.[12] speaks about the absence of an algorithm for creating angulation which the lower leg can endure without consequences and complications. There are several factors affecting the degree of deformation created including the location of the fracture, soft tissue oedema, fracture geometry and other associated complications.

The need to determine the type and size of the components of the artificially created deformation depends on the localization, shape and size of the soft tissue defect. In turn, the mounting of the external fixation device so as to complement the creation of deformity will depend on where the pins and wires are inserted and the positioning of the reference and corresponding rings.

The proposal to supplement an acute shortening with chronic or gradual[15,22–24] deserves attention. In acute trauma, the gradual shortening is limited in time to 72 hours as definitive closure of the wound should be accomplished in that time in order to reduce the risk of deep infection.[5,7] The method of using this combination of methods may be considered for cases of the consequences of trauma and reconstructive interventions, for example, after necrosis of free flaps, or for chronic wounds with contraindications to traditional plastic methods, etc.

The best device for correcting deformities created by ADCr, according to most authors, is the Ilizarov apparatus.[8,14–16,18,22–24,26,32,35–39] Acute shortening alone produces a simple one-plane deformity (the shortening) whereas additional angulation gives a two-plane two-component deformity, viz., shortening and angulation in two planes (oblique-plane angulation). To correct each component of the deformity using Ilizarov method, oblique plane hinges or sequential positioning of hinges in two separate planes with partial reassembly of the apparatus is needed. Each stage of the correction requires X-ray confirmation of its effectiveness.[40,41] If a rotational component is added to the axial shortening and angulation, then a complex multi-component multi-plane deformity is created. According to some reports, each additional component of the deformity can potentially reduce the simplicity and accuracy of correction by the Ilizarov apparatus; from 0% for complex (multi-plane multicomponent) deformities to 79% for simple deformities.[41,42] One of the solutions to the problem of correcting complex deformities which are created after closing a soft tissue defect using the ADCr method is the use of circular fixator hexapods. The Taylor spatial frame (TSF) was the only hexapod system described in the literature review.[11–13,15,27,43,44] The uses of the TSF for the correction of temporary deformities created for closing soft tissue defects have the following disadvantages:

- TSF struts are not compatible with other types and manufacturer of the rings except that designed specifically for TSF struts.
- The difficulty of fixing struts to stabilizing and “dummy” rings.
- Some difficulty in using the software with a non-orthogonal position of the reference ring.

At the present time, there is a need to use both the Ilizarov apparatus and that of circular fixator hexapods, despite both operating on fundamentally different platforms, for the creation of temporary limb deformities such as to enable wound closure in open fractures, and for their use in resolving these deformities.

Further research into acute limb shortening will eventually produce an algorithm for the use of ADCr. This will include indications and contraindications, equipment type, the optimum technique for performing each of the stages, postoperative management and the prevention of errors and complications. Such an algorithm should improve the results of treatment of these patients.

Conclusion

The method of creating a temporary artificial deformity (ADCr) is an alternative for situations where closure of a soft tissue defect with a free or rotated soft tissue flap is not possible. A ring external fixator is the optimal device for correcting the limb deformity that is created. Further research and clinical use of the ADCr method will enable an algorithm to be developed to establish the optimum indications, devices, technique and after-care for this strategy.

Author Contributions

All authors contributed significantly to the review. Leonid Solomin was responsible for the conception of this review and provided advice throughout the review; Konstantins Plotnikovs conducted the entire review with Jevgenijs Movcans as second reviewer. All authors were involved with the final manuscript.

Statement on Ethics Approval

This study was approved by ethics committee of Riga East Clinical University Hospital. Approval number: 6-A/19 (12.07.2019. Riga).

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