The aim of this study was to present two patients with lower limb posttraumatic angular deformity treated by dynamic hinged external fixation. CD-V mode Mitkovic type external fixator had been used in both cases for correction of these deformities. The method is based on hemicallotasis – bone callus distraction after a partial transversal bone cut (hemocorticotomy). The first patient had varus-recurvatum posttraumatic deformity of the ankle joint. Operation time was 65 min and hospital stay was 9 days. Superficial pin-track infection was resolved by the pin removal and by daily wound toilette. The second patient had varus-antecurvatum malunion deformity of the femoral diaphysis. Operation time was 50 min and hospital stay was 6 days. Mild knee contracture had been successfully treated by physical therapy. Angular deformity correction had been performed by distraction (for the first patient) and compression (for the second patient) in the fixator frame. Hemicallotasis of femur or tibia using CD-V mode Mitkovic type external fixator is a good alternative in the treatment of posttraumatic lower limb angular deformities, providing minimal surgical trauma and maximal use of the bone osteogenetic capacity. Gradual compression or distraction in the fixator frame allows to perform accurate angular correction in both coronal and sagittal plane in one act.

Key words: hemicallotasis, gradual angular correction, external fixation

INTRODUCTION

Knee joint is one of the most exposed joints to mechanical stress due to its being almost all body weight support during the gait. Varus and valgus deformities of lower limb result in medial or lateral displacement of the mechanical axis from its physiological position. Mechanical axis is the line connecting centre of the femoral head and centre of the ankle joint, normally passing through the middle of the knee. Changes of mechanical axis position lead to excessive load generation in one part of the knee articular surface. Hence surgical correction of aforesaid deformities should be corrected as soon as possible to prevent osteoarthritic changes in the knee joint.\textsuperscript{1,2} Surgical correction of these deformities is mostly performed by a bone wedge osteotomy. There are closed and open wedge osteotomy methods. Closed wedge method is based on a bone wedge extraction and internal fixation upon closure of resulting bone gap. Open wedge method is based on full or partial transversal bone cut and afterward angular opening at the cut place. Open wedge osteotomy can be accompanied by internal fixation, but also by external fixation method.\textsuperscript{3} External fixators with some dynamic components in the frame are giving an opportunity to perform gradual open wedge angular correction. This type of dynamic external fixation is based on the process called “hemicallotasis” - gradual stretching of the bone callus formed at the side of a partial transversal bone cut (hemocorticotomy).\textsuperscript{4,11}

Posttraumatic lower limb angular deformities are desirable to be corrected with a minimally invasive surgical approach in the area of previous trauma, due to some previously spent tissue regeneration potentials. The method of external fixation makes possible to perform the required minimally invasive approach. Authors of this paper are presenting the method of gradual posttraumatic lower limb angular deformities correction by hemicallotasis using CD-V mode Mitkovic type external fixator. Standard mode of Mitkovic type external fixator has been approved as a simply adjustable device in the treatment of bone fractures. If necessary, standard mode fixator frame can be easily replaced with the CD-V mode fixator frame. Thus a more rigid fixation can be simply transformed to an angular-dynamic fixation without the need for pins displacement.
PATIENTS AND METHODS

Two patients treated for posttraumatic lower leg angular deformity correction are presented in this study. CD-V mode of Mitkovic type external fixator was used in all cases. This mode differs from the standard mode of Mitkovic type external fixator in the addition of hinge joint and CD (compression-distraction) device in the bar of fixator frame (standard mode of Mitkovic type external fixator has three basic components in its frame – bar, clamp carrier and clamp). CD-V (addition of “V” letter in the name refers to “varus-valgus” deformity correction) mode of Mitkovic type external fixator can often be applied without the need for clamp carriers use (Figure 1). Haemicorticotomy is performed through the incision of about 3 cm. Bone cortex is first drilled by 2-3 holes using 3.2 mm diameter drill bit just at the side of incision and these holes are after connected in the cut line using an orthopaedic chiseal. Compression or distraction in the frame of a hinged external fixator results in an angular opening of the bone at the place of its previously performed partial cut (Figure 2). Bone opening at the side of hemicorticotomy can be confirmed intraoperatively by a manual maneuver but there have to be careful not to induce full bone breakage.

Patient No. 1 was 64 years old man with posttraumatic angular deformity of the right ankle joint. He firstly suffered an ankle fracture in the traffic injury. The fracture was primarily treated by ORIF, but varus-recurvatum deformity of the ankle joint had been observed after the implant removal. Next step of the treatment included CD-V mode Mitkovic type external fixator application upon distal fibular osteotomy and distal tibial medial hemicorticotomy. The fixator was set on the medial side, because of tibial subcutaneous location making pins application most safe on that side of the lower leg. Hinge joint of the fixator frame was set in oblique position (in resulting plane of both coronal and sagittal plane) to enable conditions for both varus and recurvatum deformity correction in one act. Operation time was 65 min. Hospital stay was 9 days. Correction was being performed by gradual distraction (1 mm per day) in the fixator frame, achieved by daily rotation of the screw in CD device. Superficial pin-track infection occurred around one distal pin and it was resolved by the pin removal and daily wound toilette. Frame of the fixator was removed 8 weeks af-
ter the surgery, but pins were left in place, in case of any redislocation. X-ray control on 10 weeks after the surgery approved good correction of the ankle angular deformity in both coronal and sagittal plane without need for further external fixation treatment (Figure 3).

Patient No. 2 was a 62-year-old woman with malunion angular deformity of the right femur. She suffered a fracture of femoral diaphysis in the traffic injury. The primary treatment by ORIF resulted in varus-antecurvatum malunion deformity. Further management had been based on the correction of this deformity by the same external fixation method as in patient No. 1. Hemicorticotomy had to be performed at medial side of the femur, but the fixator was placed on lateral side because it is more safe to set fixator pins from the lateral than from the medial femoral side. The haemicorticotomy was realized distally from the femoral malunion place. This, because bone has better osteogenetic potential in its metaphyseal part and because of some previously damaged tissue regeneration potentials in diaphyseal fracture area. Hinge joint of the fixator frame was set in resulting plane of both coronal and sagittal plane to enable both varus and antecurvatum deformity correction. Operation time was 50 min. Hospital stay was 6 days. In this case, correction was being performed by gradual compression (1 mm per day) in the fixator frame. Frame of the fixator was removed 10 weeks after the surgery. X-ray control on 12 weeks after the surgery approved good correction of both varus and antecurvatum femoral angular deformity and pins were extracted later. Mild knee contracture had been observed but after physical therapy she recovered previous knee range of movement (Figure 4).

**DISCUSSION**

Orientation of a dynamic external fixator hinge joint has been approved as a factor determining the direction of lower limb angular deformity correction. Thus hinge joint orientation in the coronal plane provides the correction of only varus/valgus deformities; hinge joint orientation in sagittal plane provides the correction of only antecurvatum/recurvatum deformities; hinge joint orientation in an oblique position (between coronal and sagittal plane) provides the correction of angular deformities in both coronal and sagittal plane.

Hence the proportion of varus/valgus and antecurvatum/recurvatum angles of an angular deformity will determine the desirable angle of the external fixator hinge joint orientation. For example, if the proportion of these two angles in an angular deformity is 1:1 than the external fixator hinge joint has to be oriented in 45 degrees between sagittal and coronal plane; if varus/valgus deformity angle is bigger than antecurvatum/recurvatum deformity than the external fixator hinge joint has to be more inclined to the coronal plane. The change of hinge joint orientation in CD-V mode Mitkovic type external fixator is possible to perform during the surgery by a simple rotation of the bar with straightened hinge joint, before clamps (and clamps carriers – if used) locking.

Dynamic external fixation using CD-V mode Mitkovic type external fixator provides an opportunity to achieve precise correction of lower limb angular deformities.

Hypercorrection can be easily modified by the change of dynamic performance direction (between compression and distraction) in the fixator frame. Possibility for these both compression and distraction process is making possible to place the fixator frame medially or laterally re-
gardless on the hemicorticotomy position. If the fixator frame is set on the same side as of hemicorticotomy than the bone opening is realized by distraction performance. And vice versa, if the fixator frame is set on the opposite side of hemi-corticotomy than the bone opening is realized by compression performance.

In open wedge osteotomy method accompanied by an external fixation, hemicorticotomy can be performed through a small incision.\(^4\)\(^5\) Also, lower limb mechanical axis can be modified by the hemicallotasis either in the level of malunion or in other level of the same bone. Hence, if the malunion is occured in diaphyseal part than hemicallotasis can be performed in metaphyseal region (metaphyseal region of the bone has better osteogenetic potential than diaphyseal, especially if some tissue regeneration potentials are spent in previous diaphyseal malunion process). Given these facts, open wedge method accompanied by a dynamic external fixation obtains minimal surgical obstruction and maximal use of the bone osteogenetic capacity.

The bar of CD-V mode Mitkovic type external fixator frame has the same diameter as the bar of the standard mode. So, if there is a need, Mitkovic type external fixation can be easily transformed from standard mode (used for fracture fixation) to angular-dynamic mode, just by changing of some frame components, without the need for pins replacement.

According to one previous study, it is suggested to place the external fixator hinge joint as more in the hemicallotasis level as possible.\(^1\)\(^2\) As more the fixator hinge joint is far from the hemicallotasis point than more mechanical tensions and hence risk for fixator deformation or bone breakage are occurred.

In presented cases one patient had pin-tract infection and other patient had mild knee contracture. Both these complication were resolved successfully with ad-

FIGURE 3
X-RAYS OF THE ANKLE FRACTURE TREATED BY ORIF (A), VARUS-RECURVATUM DEFORMITY AFTER PLATES REMOVAL (B), HEMICALLOTASIS IN BOTH CORONAL AND SAGITAL PLANE PERFORMED USING CD-V MODE MITKOVIC TYPE EXTERNAL FIXATOR AFTER FIBULAR OSTEOTOMY AND HEMICORTICOTOMY IN DISTAL METAPHYSEAL PART OF TIBIA (C), ANGULAR CORRECTION 2 WEEKS AFTER THE FIXATOR FRAME REMOVAL (D),
equate treatment. Regarding other studies referred to complications following hemicallotasis by dynamic external fixation, it is suggested also to take a care about deep vein thrombosis, deep infection, peroneal nerve symptoms and septic arthritis. In rare cases, after achieved angular correction, external fixator can be replaced by a seldinamysible internal fixator (SIF) or some other internal fixation implant.

**CONCLUSION**

Hemicallotasis of femur or tibia using CD-V mode Mitkovic type external fixator is a good alternative in the treatment of posttraumatic lower limb angular deformities. This type of dynamic hinged external fixation provides minimal surgical trauma and maximal use of the bone osteogenetic capacity. Gradual compression or distraction in the fixator frame allows to perform accurate angular correction. Angular correction in both coronal and sagittal plane is possible to achieve in one act regardless of pins position.

**SUMMARY**

PRIKAZ DVA SLUÈAJA KOREKCIJE POSTTRAUMATSKIH UGAONIH DEFORMITETA DONJIH EKSTREMITETA DINAMIÈKOM SPOLJNOM FIKSACIJOM

Predmet ovog rada je prikaz 2 bolesnika sa posttraumatskim angularnim deformitetom donjeg ekstremiteta leèenih metodom dinamièke spoljne fiksacije. Kod oba sluèaja je korišèen CD-V spoljni fiksator po Mitkovicu. Osnovu ovog metoda èini hemikalotaza-postepeno ras-

Ključne reči: hemikalotaza, postepena ugaona korekcija, spoljna fiksacija

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