Dilemmas in the treatment of tibial diaphyseal fractures

Predrag Grubor¹, Milan Grubor², Rade Tanjga²
¹Traumatology Clinic, Clinical Centre Banja Luka
²Medical School, Banja Luka University

INTRODUCTION

Fractures of the lower leg or the tibia itself, accompanied by fractures of the radius at typical sites are the most common type of fractures. They occur at any age, more frequently in young people. Fractures that are considered tibial diaphyseal fractures are those that occur between the knee and ankle joint. We distinguish fractures of the upper, medial and lower thirds of the tibia. A fracture occurs through direct and indirect application of force. Direct fractures are usually transverse, slightly oblique or comminuted, while indirect ones are torsional - rotational fractures. A fracture can easily turn into an open one due to the direct contact of the tibia with the skin.

Tibial fractures come in different forms and sizes. Every fracture must be treated individually. When determining the treatment for the tibia, the following must be taken into account: localisation and type of fracture, condition of the soft tissue surrounding the fracture, general condition of the patient, ...

There are different non-surgical and surgical methods for treating tibial fractures. Non-surgical treatment means treatment with plaster cast immobilisation, extension, ... In addition to a good healing tendency, the advantages of conservative treatment lie in avoiding potential risks that come with surgical treatment, such as infections. Surgical

Conclusion: On the basis of the results of surgical treatment for the given series, the number of surgical interventions, the price of osteosynthetic material, my preferences in treating tibial diaphyseal fractures would be as follows: Mitkovic external fixator type M20, anti-rotation intramedullary nails and locking compression plate. Conservative treatment is indicated when the X-ray examination confirms that the fragments have a position acceptable for conservative treatment with plaster cast.

Key words: M20, anti-rotation intramedullary nails, LCP
treatment is the most common form of treatment nowadays. External skeletal fixation, using a fixator, and internal fixation, using anti-rotation intramedullary nails and locking compression plates (LCP), are most frequently used to stabilise bone fragments of the tibial diaphysis.

OBJECTIVE

The study is aimed at using the examined sample to make the most efficient medical and the most economical choice in the treatment of tibial diaphyseal fractures.

MATERIAL AND METHODS

The series comprises a retrospective and prospective study of the treatment diaphyseal of fresh tibial fractures in 131 patients, 31 women (23.66%) and 100 men (76.34%) of the average age of 37.89, treated at the Traumatology Clinic in Banja Luka in the period between 1st March 2010 and 1st March 2013. Seventy-nine patients (60.31%) suffered a fracture of the right tibia and 52 (39.69%) of the left. Thirty-eight patients (29.01%) in the examined sample suffered a polytrauma. Thirty-one patients (23.66%) suffered a transverse fracture, 53 (40.46%) oblique, 32 (24.43%) spiral and 15 patients (11.45%) suffered a segmental/comminuted fracture. There were open fractures in 13 patients (9.92%). The following is the incidence of open tibial fractures: Gustilo Grade-I fractures in 7 (5.34%), Gustilo Grade-II in 5 (3.82%) and Gustilo Grade-III in 1 patient (0.76%). All patients with open fractures were treated with Mitkovic external fixator type M20.

The nineteen patients (14.50%) whose initial x-ray examinations confirmed that the fragments had an acceptable position for the treatment with plaster cast were treated conservatively. On average, the definitive plaster cast was placed on the sixth day, over the existing plaster cast, and a follow-up x-ray examination was performed. If the x-ray confirmed there was no dislocation of the fragment, the treatment continued at home, with a recommendation to walk with axillary crutches (non-weight bearing) in order to satisfy basic needs. The first follow-up was performed 15 days later, with the x-ray shot through the cast. Negative x-ray findings enable the patient to walk with axillary crutches, with up to 5-kg weight bearing. Follow-ups were performed every 15 days, including x-ray. After six weeks, the same plaster cast was shortened to below the knee, and the follow-up after four weeks was performed with an x-ray examination of the tibia without the plaster cast. Radiographic and clinical findings indicated the need for further treatment: without a plaster cast or with a functional plaster cast until full recovery. (Picture 1)

One hundred and twelve tibiae (85.50%) were treated surgically: 74 with Mitkovic external fixator type M20 (56.49%) (Picture 1), 22 with anti-rotation intramedullary nails (16.79%), and 16 with locking compression plate (LCP) (12.21%).

General anaesthesia was used in 46 patients (35.11%), while spinal anaesthesia was used in 85 of them (64.89%).

PICTURE 1:
CLINICAL RESULT THREE MONTHS AFTER TIBIAL FRACTURES TREATED WITH MITKOVIC EXTERNAL FIXATOR TYPE M20

GRAPH 1:
ASSESSMENT OF TREATMENT RESULTS FOR MITKOVIC FIXATOR TYPE M20 ACCORDING TO MODIFIED KARLSTROM-OLERUD SCORING SYSTEM

We did not use a portable x-ray machine with a display to assist us in performing closed repositioning of fractures followed by stabilisation. We are of the opinion that a tissue trauma is greater in case of closed repositioning because the first attempt to reposition the fragments is rarely successful. Also, the risk of x-ray radiation is not insignificant for the surgical team. A semicircular anterolateral skin incision above the fracture and across the tibial muscle results in a minor soft tissue trauma, facilitates safer repositioning and stabilisation of the fracture under direct visualisation.
When we, after repositioning the bone fracture, placed an external fixator type M20, we used bone holders to maintain the temporary reposition, and we performed definitive stabilisation using the M205. The pins were inserted through approximately 1-cm long skin incisions, two above (anteroposteriorly and mediolaterally) and two below the fracture site. We used six pins for segmental and comminuted fractures. The pins for the external fixator type M20 were inserted at the incision sites. The clamps, holders and M20 frame were placed 5. The bone holders were then removed, and the fracture stability, drain and wound stitches by layers were checked.

The method of work with anti-rotation intramedullary nails: we made semicircular skin incisions and repositioned the fracture which we then held with bone holders. We flexed the knee to 900 and verified the tibial tuberosity. We made a short skin incision above the patellar ligament, through which we approached the tibia using a reamer, making space to apply a locked intramedullary nail. The intramedullary nail was placed through the medullary canal and it kept the tibial fracture stabilised, and additional screws below and above the fracture stabilised it further. In addition to the infrapatellar incision used in order to place the locked intramedullary nail, the patients also had small incisions below the knee and above the ankle joint through which anti-rotation screws were inserted. The average length of the locked intramedullary nail was between 28 and 36 centimetres and the diameter was between 8 and 9 millimetres.

LCP fixation: It was placed subcutaneously following the repositioning. There was a need to make small skin incisions proximally and distally from the fracture in order to insert the screws.

The average time of surgery to place anti-rotation intramedullary nails amounted to approximately 86 minutes, with the help of two surgical assistants. One assistant was needed to reposition and apply the external fixator type M20 in approximately 25 minutes. LCP fixation was performed with the help of one assistant and it took approximately 35 minutes.

All operated patients were mobilised on the first postoperative day, and the average length of inpatient stay was four days. For the patients whose fractures were treated conservatively, the length of inpatient stay amounted to an average of seven days.

All surgically treated patients received antibiotics for five days on average, and all patients received medicamentous thromboembolism prophylaxis.

RESULTS

Out of the 22 tibial fractures treated with anti-rotation intramedullary nails, one patient (4.55%) had a deep infection and the intramedullary nail had to be removed. In 3 patients (13.64%) there was a diastasis at the fracture site and the bone union process was prolonged. We revitalised the fracture by removing the proximal screws, in order to facilitate fracture healing by dynamisation. In two of these three patients (9.09%) the treatment finished with pseudoarthrosis. As for the fractures in the proximal third of the tibia, 1 patient (4.44%) had an antecurvatum deformity and skin dehiscence. Three patients (13.64%) suffered transient contractures in the knee, and 7 (31.82%) suffered knee pain. Three patients (42.85%) suffered pain when kneeling and 4 (57.14%) when resting. This pain was accompanied by a hypertrophic infrapatellar scar. The average period for fracture healing was 17.2 weeks.

On average, the locked intramedullary nail was removed 9.5 months after its placement, under general anaesthesia.
The criteria for assessing the treatment results were determined according to the modified Karlstrom-Olerud scoring system, which covers five subjective symptoms and seven objective signs. According to this scoring system, the results of treatment with anti-rotation intramedullary nails in the series of 22 tibiae were as follows: in 15 patients (68.18%) they were excellent, in 3 (13.64%) good, and in 4 (18.18%) they were poor. (Table 1)

The price of a locked intramedullary nail amounts to 480 and it is disposable.

Out of the 74 tibial fractures treated with a Mitkovic external fixator type M20, infection occurred in 16 nails. In 13 nails, infection healed due to adequate hygienic measures around the nails, and three nails were re-assembled. There was no deep infection or skin necrosis. In 3 patients (4.05%) the treatment resulted in pseudoarthrosis and one tibia was in a valgus position of approximately 8 degrees. There were no contractures, knee pain or pain in the ankle joint. The healing period for tibial fractures was 16.9 weeks. The fixator type M20 was removed without anaesthesia in the surgery after five months.

According to the Karlstrom-Olerud scoring system, the results for the treatment of the series of 74 tibia with Mitkovic’s external fixators type M20 are as follows: 62 (83.78%) were excellent, 9 (12.16%) were good, and 3 (4.05%) were poor. (Graph 1)

The price of a locked intramedullary nail amounts to 480 and it is disposable.

Out of the 16 tibiae treated with LCP, 2 patients (12.50%) suffered a deep infection and the plate had to be removed. The treatment was continued using an external fixator. One patient suffered from skin necrosis, and two from transient dehisence. The treatment resulted in pseudoarthrosis in 2 patients (12.20%). The average time needed for a fracture to heal was 18.2 weeks. On average, the plate was removed in the operating theatre after 10.2 months, under anaesthesia.

The results obtained according to the Karlstrom-Olerud scoring system for the treatment of the series of 16 tibia with LCP are as follows: 10 (62.50%) were excellent, 2 (12.50%) were good, and 4 (25.00%) were poor. (Table 2: Assessment of treatment results for LCP according to modified Karlstrom-Olerud scoring system)

The price of a locking compression plate amounts to 750. It can be used on one patient and is disposable.

As for the 19 tibiae treated conservatively, thrombophlebitis occurred in 2 patients (10.53%), and 3 patients (15.79%) suffered dislocation of fragment(s) and their treatment continued surgically. There were 3 patients (15.79%) with CRPS Type II, and there was a valgus deformity greater than 5 degrees in 1 patient (5.26%). Three patients (15%) had knee and ankle joint contractures, and 1 patient (5.26%) had ankle joint pain. The mean time for fracture healing in a plaster cast amounted to 16.1 weeks.

According to the Karlstrom-Olerud scoring system, the results for the series of 19 tibia treated with a plaster cast were as follows: 12 patients (63.16%) had excellent results, 2 (10.53%) had good, and 5 (26.32%) had poor re-

Graph 2: Assessment of results of complete treatment
results. Table 3: Assessment of results of conservative treatment with plaster cast according to modified Karlstrom-Olerud scoring system

The price of a plaster cast for treating tibial fractures amounts to 25.

According to the Karlstrom-Olerud scoring system, the final treatment results for the series comprising 131 patients treated for tibial fractures with fixator type M20, locked intramedullary nail, LCP and plaster cast are as follows: excellent in 99 patients (75.57%), good in 17 (12.98%) and poor in 15 (11.45%).

The total treatment results for the patients in the examined sample, by type of surgical and conservative treatment, are shown in Graph 2.

By comparing research groups, the Mitkovic external fixator type M20 seems to have an advantage compared to the anti-rotation intramedullary nail and LCP in terms of the number of surgical interventions. At the same time, the Mitkovic external fixator type M20 takes precedence over other treatment methods (anti-rotation intramedullary nail and LCP) in terms of its price, too. Although the price of the Mitkovic external fixator type M20 is the highest and it amounts to 950, the fact that the M20 can be used multiple times (in the author’s experience minimum five times, which in turn amounts to maximum 190 per treatment) shows that the application of the M20 is the most convenient, given the price of osteosynthetic material and possibilities for multiple use.

The results of the comparative analysis of the treatment results by type of surgery are given in Table 4.

The following values (results) were taken as the outcomes: duration of surgery (min), number of surgical assistants, mobilisation and weight-bearing time, average length of inpatient stay, average amount of spent blood (ml), complications, mean fracture healing time (weeks), price (EUR), treatment quality score.

Every outcome (result) is accompanied by a ranking, using the minimum (maximum) result criterion. The summed score of individual rankings was calculated afterwards and the treatment quality score was calculated based on that (Graph 3).

The ranking for specific types of surgery was made on the basis of the summed score of individual rankings and it is as follows: Mitkovic external fixator type M20, Anti-rotation intramedullary nails and locking compression plate.

DISCUSSION

Non-surgical treatment of tibial fractures with a functional plaster cast introduced by Sarmiento is still very popular, and it is widely applicable in everyday practice of orthopaedic trauma. However, treatment with a functional plaster cast was not the best solution for unstable fractures which lost their accomplished repositioning in the plaster cast and in turn resulted in non-union, shortening and unacceptable angulation.

### TABLE 4

<table>
<thead>
<tr>
<th>Type of surgery</th>
<th>Duration of surgery (min)</th>
<th>Number of surgical assistants</th>
<th>Mobilisation and weight-bearing time</th>
<th>Average length of inpatient stay</th>
<th>Average amount of spent blood (ml)</th>
<th>Mean fracture healing time (weeks)</th>
<th>Price (EUR)</th>
<th>Treatment quality score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anti-rotation intramedullary nail</td>
<td>320</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>17</td>
<td>2</td>
<td>480</td>
<td>2</td>
</tr>
<tr>
<td>Mitkovic fixator type M20</td>
<td>25</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>16.9</td>
<td>1</td>
</tr>
<tr>
<td>LCP</td>
<td>35</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>19.2</td>
<td>3</td>
</tr>
</tbody>
</table>

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Surgical treatment of tibial diaphyseal fractures usually leads to the union of fractures, with no consequences on the living potential and work capability. The most commonly used operative methods for tibial diaphyseal fractures are intramedullary fixation (3), LCP fixation and external skeletal fixation with different types of external skeletal fixators (Hoffmann, Ilizarov, AO, Orthofix). Out of the 44 closed tibial diaphyseal fractures and Gustilo Grade-I and Grade-II open fractures that Shaw et al. treated with external skeletal fixation all fractures healed.

Keating et al. had union in 95% of tibial diaphyseal fractures after treating 100 fractures (47 and 53 closed and open, respectively) with Orthofix external skeletal fixators. In the same series, the authors had 6% fracture non-unions, and fracture malunions in 14% of closed and 32% of open fractures.

Krettek et al. had 10.9% fracture non-unions after external skeletal fixation of 202 tibial diaphyseal fractures (70 and 132 closed and open fractures, respectively). Placing a Mitkovic external skeletal fixator takes a short time, there is no blood loss, there is minimum damage to bone vascularisation, and post-operative length of inpatient stay is short.

Bone treatment may last between six and sixteen weeks. However, returning the bone strength and its ability to sustain a heavy load may take as long as up to a year. Once we clinically and radiographically establish that the bone has healed, the patient may resume everyday activities. It is important to instruct the patient not to overload the leg until the full strength has been regained.

In the treatment of 130 tibiae, Koprivcic et al. treated 125 surgically and 5 conservatively. A hundred and thirteen surgically treated fractures were treated with screws and plates, 9 with intramedullary osteosynthesis and 3 with external fixator. Out of the 130 patients, 117 fractures (90.00%) healed without complications, 2 (1.54%) were malunited, 4 (3.08%) sustained infection, and pseudoarthrosis occurred in 3 patients (2.31%). In 4 patients (3.08%) osteosynthesis was insufficient.

The use of antibiotics is one of the key factors in the treatment of open tibial fractures. In a prospective and retrospective study including 333 open tibial fractures, Gustilo decreased the rate of infections to 2.3% through the use of antibiotics, compared to 13.9% infections in the antibiotic-free group. The choice of antibiotics should be based on the microbiological findings.

The dynamic compression plate makes full access to the fracture possible, with no risk of infection. The new generation of dynamic compression plate, which follow the angulation of the tibia, provide an adequate stability and offer new possibilities in tibial treatment, especially when used as "internal fixators". The application of the dynamic compression plate as an "internal fixator" using a minimally invasive technique does not cause the compression of the implant onto the bone. This in turn provides biomechanical advantages: sufficient stability which allows a quick healing of the bone accompanied by a callus.

The locked intramedullary nail can serve as the gold standard for the treatment of open and closed tibial fractures. When compared to the external fixator, there are no major differences in terms of the time necessary for the healing of the fractured bone or in terms of the infection rate.

CONCLUSION

The Mitkovic external skeletal fixator type M20 is unilateral, simple and efficient at treating all types of open, closed and unstable tibial diaphyseal fractures. This type of treatment facilitates safe fracture union, early mobilisation, rehabilitation and weight-bearing of the operated patient. The fracture fixation is unilateral with the pins oriented convergently, and there is a possibility of compression and distraction, which in the process of fracture healing gives a possibility to adjust to biomechanical conditions - by dynamisation of the instrument. It is re-usable, which makes the treatment cheaper.

The intramedullary nail with locking screws requires an extremely good surgical technique which is sensitive (delicate) and requires an adequate instrumentarium. It can be used for the treatment of open, closed and segmental tibial fractures. The price of the instrument, two surgical interventions and the results of treatment with the locked intramedullary nail, compared to the M20, are statistically significant.

The locking compression plate is indicated for closed fractures, it requires a solid surgical technique and an adequate instrumentarium. It cannot be used in segmental fractures due to the price, two surgical interventions are required for complete healing, and the results, compared to the M20, are statistically significant.

Conservative treatment of tibial fractures is the method of choice in patients if the x-ray examination confirms that the fragments have an acceptable position for conservative treatment with plaster cast. This way we avoid any possible intraoperative and postoperative complications of surgical treatment. This type of treatment is the cheapest.

In the examined series, the Mitkovic external fixator type M20 is the method of choice in surgical treatment of tibial fractures. The locked intramedullary nail would take
the second place, and the locking compression plate would follow.

**SUMMARY**

**DILEME U LIJEČENJU PRELOMA DIJAFIZE POTKOLJENICE**

Uvod: Prelomi potkoljenice uz prelom radijskog tipefnog mjestu najčešće su prelomi. Cilj rada: Na ispitivanom uzorku doći do efikasnog i ekonomsko prihvatljivog izbora u liječenju preloma dijafize potkoljenice. Materijal i metode: Seriju čini retrospektivno prospektivna studija liječenja 131 svježa preloma tibije; 31 (23,66%) žena i 100 (76,34%) muškaraca, prosječne životne dobi 37,89 godina. Konzervativno je liječeno 19 (14,50%), a 112 (85,50%) hirurški: intramedularnim antirotacionim klinovima 22 (16,79%), spoljnim fiksatorom po Mitkoviću M20 74 (56,49%), zaključanim kompresivnim pločama (LCP) 16 (12,21%). Opšta anestezija korišćena je kod 46 (35,11%) a spinalna kod 85 (64,89%) bolesnika. Rezultati: Na osnovu Karlstromovog i Olerudovog bodovnog sistema, rezultati liječenja su bili: intramedularnim antirotacionim klinovima 22 potkoljenice: 15 (68,18%) odličan, 3 (13,64%) dobar, 4 (18,18%) loš. Rezultati liječenja 74 potkoljenice spoljnim fiksatorom po Mitkoviću M20; 62 (83,78%) odličan rezultat, 9 (12,16%) dobar, 3 (4,05%) loš. Rezultati liječenja 16 pacijenata LCP pločama: kod 10 (62,50%) je bio odličan rezultat, 2 (12,50%) dobar, 4 (25,00%) loš. Rezultati liječenja 19 potkoljenice gipsom: kod 12 (63,16%) odličan rezultat, 5 (26,32%) loš. Definirani rezultati liječenja 131 polomljenih potkoljenica navedenim tehnikama bio je: odličan kod 99 (75,57%), dobar kod 17 (12,98%) a loš kod 15 (11,45%) pacijenata. Diskusija: Postoje različiti kontroverzi i nezgode u liječenju preloma dijafize potkoljenice. Zaključak: Na osnovu rezultata hirurškog liječenja navedenih serija, broja hirurških zahvata, cijene osteosintetskog materijala, prednost u liječenju zatvorenih i otvorenih preloma dijafize potkoljenice dao bih: spoljnjem fiksatorom po Mitkoviću M20, intramedularnim antirotacionim klinovima i LCP pločama. Konzervativno liječenje je indikovano kada radiografija potvrđuje da fragmenti imaju prihvatljiv položaj za konzervativno liječenje gipsom.

Ključne riječi: M20, intramedularni antirotacioni klin, LCP

**REFERENCES**