



*Review*

## **SURGICAL TREATMENT OF COMPLEX META-DIAPHYSEAL TIBIAL FRACTURES – CURRENT STATE OF THE ART AND NEW TREATMENT MODALITIES**

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### **ABSTRACT**

Fractures of a meta-diaphyseal region of the tibia are still challenging in terms of safe, fast, minimal invasive, low - risk surgical treatment. The unstable meta diaphyseal tibial fractures affect proximal and distal one-third of the tibia and result from high-energy trauma, usually combined with severe soft tissue injury. Treatment strategies include mostly operative approaches with various contemporary surgical instrumentations and modern techniques for definitive fracture repair, achieving primary or secondary bone union and better quality of life for patients. In the last decade, new techniques for definitive external plate fixation have been introduced as a part of contemporary trauma armamentarium with good and excellent outcomes.

**Key words:** Tibia, Fractures, Intramedullary nailing, MIPPO

### **INTRODUCTION**

The unstable meta diaphyseal tibial fractures affect proximal and distal one-third of the tibia and result from high-energy trauma, motor vehicle accidents, or falls from heights. They can have long-term adverse consequences associated with significant socioeconomic costs [1]. The unstable meta-diaphyseal tibial fractures are usually accompanied by severe soft tissue trauma, which presents a significant challenge to the treating orthopaedic trauma surgeon [2, 3]. The soft tissues surrounding the knee joint and ankle are easily affected by trauma, and subsequent surgical fracture fixation further disrupts the primary injured blood supply, which is a prerequisite for delayed bone union or complications associated with postoperative wound healing [4]. The contemporary orthopedic treatment has been separated into two different directions, one is conservative or non-operative, by means of closed reduction followed by cast Immobilization of the injured extremity and surgical, by means of open reduction and internal fixation (ORIF) with plates, with

interlocking intramedullary nails (IMN) or by using various external fixation instrumentations. Conservative treatment protocols require a longer time of cast immobilisation, confining patients to bed, had disadvantages in terms of cast loosening after oedema subsidence, followed by secondary fracture dislocation within the cast. Non-operative treatment indications include stable tibial fractures with minimal fracture dislocation, without intra-articular involvement or articular comminution with fragments. The open surgical fracture reduction followed by internal fixation - ORIF requires extensive operative soft tissue exposure, and further impairs regional blood supply. That is a prerequisite for a serious number of complications, in terms of wound breakdown, superficial and deep infection, followed by non-union, or longer treatment period of time with impaired work capacity [5]. Interlocking intramedullary nailing (IMN) is another metal instrumentation, that provides stabilization of meta-diaphyseal multifragmentary fractures with adequate fracture alignment and restoration of limb length discrepancies [6]. The risks of IMN are determined by the shape and width of the tibial medullary cavity, resembling an hourglass, widened in the proximal and distal metaphyseal zones and narrowed in the

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diaphyseal isthmus. From scientific point of view, which is the reason for the high incidence of axial malalignment, fixation breakdown and anterior knee pain, following the IM nailing Minimally invasive percutaneous plate osteosynthesis - MIPPO is performed through small surgical incisions and is more sparing with respect to the bone biology, and the adjacent soft tissues [7]. Theoretically, a shorter time frames for bone healing are expected to occur. Despite being anatomically pre-contoured, locking plates - LCP may permeate under the skin, and cause subsequent surgical wound problems at the surgical site, skin breakage, followed by superficial or deep peri implant infections with delayed or nonunion or osteomyelitis.

**NOVEL TECHNIQUES ARISING.**

The contemporary (standard) LCP plate functions as an internal-external splint, and the locking screws provide absolute stability to the construct [8] similar to Schantz pins, which are also steadily fixed into connecting bars [9]. In the last few years, a novel method for definitive monolateral external fixation, using

anatomically pre-contoured metaphyseal locking compression plates (LISS-LCP), as a one-staged external locked splinting device has been reported [10,11]. The locking plates are placed over the tibial skin, supercutaneously, after adequate closed fracture reduction is achieved and stabilizes the fracture site until secondary bone union appears [12].

**COMPARATIVE ANALYSIS OF STANDARD TREATMENT METHODS.**

**1. Proximal tibial fractures with an intra-articular involvement.**

Bicondylar tibial plateau fractures as a result of high-energy trauma are followed by significant soft tissue damage. The choice of the appropriate time for definitive surgical fixation is based on the subjective assessment of the soft tissue condition in the area of injury. Immediate definitive fixation, due to additional damage to the soft tissue envelope, results in a high risk of wound complications and deep infections. Therefore, staged treatment following natural repair of damaged soft tissues is a commonly used surgical strategy for diminishing the risk of severe complications (**Figure 1**).



**Figure1.** High-energy, simple intra-articular bicondylar tibial fracture with severe soft tissue injury - AO/OTA - 41C2.

It consists of the initial provisional external fixation by the placement of a temporary external fixator, bridging the knee joint, followed by definitive fixation within 1 to 3 weeks from the initial trauma. The modern surgical technique that avoids extensile open surgical interventions is percutaneous, minimally invasive plating with pre-contoured LCP plates - MIPPO. There are disadvantages with the staged treatment in terms of higher costs due to additional surgical procedures, with expensive implants, with prolonged or repeated hospitalizations. Therefore, delayed or staged treatment may increase the difficulty of fracture reduction. On the contrary, early definitive external fixation might be the method of choice

in carefully selected patients with insignificant risk of soft tissue complications. [13].

Bicondylar tibial plateau fractures type AO/OTA 41 C or Schatzker type V and VI are severe injuries in the knee joint region. A surgical approach is generally accepted to minimize the risk of joint contractures, deformities, and early osteo arthritis but still, there is no consensus on the optimal surgical technique. The conventional ORIF technique using two plates yields equivocal-similar results, but the degree of the additional soft tissue trauma produces unfavorable soft tissue conditions followed by wound complications. Despite restoring the anatomic joint congruity and achieving a good articular surface by open reduction and stable fixation according to the AO-

principles and early mobilization of the knee joint depends on the condition of the surrounding soft tissues [14].

Initial enthusiasm for the introduction of MIPPO with locking plates was followed by scepticism due to the high incidence of complications, such as deep infection in up to 18%, malalignment in up to 23%, the need for implant removal in up to 30% and irritation around the implant site in up to 12% of cases. Furthermore, clinical and biomechanical studies have shown that the results of MIPPO with one lateral LP are not superior to traditional ORIF with two plates. The need for lateral and medial incisions, the volume of the implant and the trauma of implant removal, along with the significant rate of infectious complications, predispose to wound healing problems when future total knee arthroplasty is required.

External fixation with a ring or hybrid fixator is also a viable method. However, patients have difficulty accepting bulky external fixators, which make knee mobilization and rehabilitation difficult and require continuous care of the skin around the screw channels. In patients with osteoporotic fractures, malunion and/or malalignment are uncommon complications. The IMN surgical technique, introduced after

biomechanical testing, combines the use of an intramedullary nail together with condylar screws to treat bicondylar fractures without joint depression [15].

Intramedullary implants distribute the axial forces evenly and allow early mobilization with partial WB, which is particularly important for the elderly patient population. Infection rates are lower with IMN than with plating or external fixation. Removal of the IMN and the canulated condylar screw is a simple surgical procedure. Results with follow-up of patients for a minimum of one year showed normal fracture healing in all patients with healing times between 10 and 22 weeks, without further complications. In the cited study, only one patient, undergone a revision fixation due to poor reduction of the articular surfaces and one condylar bolt was removed after fracture healing due to irritation at the insertion site. In all patients, the range of motion in the knee joint was restored without prolonged physiotherapy and with full WB of the injured limb after the 5th postoperative month [15].

The following table systematizes the results of several authors on the relationship between intra-articular congruency and functional outcomes in different therapeutic modalities (**Table 1**).

**Table 1.** Degree of articular incongruency and functional outcomes from data published from the literature [16].

Autor	Cases	Fx class	Tx modality	Functional Score	Final results
Waddell et al. (1981)	95	Lat - 75 Med - 8 Bicondylar - 12	ORIF 72%, Non op 28%	Good and excellent results -ROM >90° of flexion, and <5° malalignment, no arthritis, no limping.	Fair with >10 mm lat.condyle joint depression
Lansinger et al. (1986)	102	Lat - 70 Med - 14 Bicondylar - 18	Operative 56%, Non op 44%	Rasmussen score	Fair with >10 mm joint depression
Honkonen (1994)	131	Lat - 68 Med - 12 Bicondylar - 51	ORIF 58%, Non op 42%	Honkonen score	Fair outcome >3 mm joint depression
Weigel et al. (2002)	18	Schatzker тип II=1, IV=1, V=1, VI=15	Limited int fix and monolateral ex fix	Iowa knee score, SF-36	No correlation
Singleton et al. (2017)	41	Schatzker тип II=19, III=2, IV=7, V=1, VI=12	ORIF 85%, CONS 15%	Iowa и Oxford scores, KOOS, WOMAC	Fair outcome >2,5 mm depression, Iowa, Oxford and KOOS scoring systems

Additionally, a slight varus tilt of up to 5° was associated with worse functional outcomes compared with an adequately restored anatomic axis, with valgus deformity of up to 5° which was better tolerated. In another study, [17]

reported the outcomes after operative or non-operative treatment of 41 patients with tibial plateau fractures A, B and C according to the AO/OTA classification. Patients with more than 2,5 mm of residual joint surface depression as

measured by coronal plane tomogram had residual pain and significantly lower functional scores on the Oxford Knee Score, Iowa Knee Score, and KOOS. A biomechanical study showed that incongruity in the lateral plateau area progressively exacerbated the valgus deformity of the knee joint, with a mean increase of  $7.6^\circ$  with a 6 mm threshold and walking with the leg extended, concomitant with a 208% increase in mean contact pressure [18]. All this is a prerequisite for the early development of arthritic changes in the knee joint [19].

The fractures of both tibial condyles are unstable and prone to dislocation with conservative treatment and that necessitates the prevalence of surgical treatment [16]. The undisplaced condyle fractures treated conservatively with dynamic bracing and protective loading had good and excellent final results [12]. Comparable results were reported for a case series of tibial plateau fractures using the ORIF technique [20]. The mean healing period or time to fracture union of the nine patients with both tibial condyle fractures followed, was approximately 3 months [20]. Seven patients had good joint surface congruity with less than 2 mm gap and two patients had a joint surface gap of 4 mm. The mean range of motion of the affected joints was  $2^\circ$  in extension and  $112^\circ$  in flexion. All patients had restored mechanical axes in sagittal and coronal planes with satisfactory condyle width. None of the patients had symptoms of knee instability. The mean postoperative Knee Society Score (KSS) was 91. There were no cases of infection in the reported group of patients. Another study compared the use of a less invasive stabilization system for metaphyseal fractures (LISS) to the conventional two-plate technique (ORIF) in 84 patients who sustained an open or closed bicondylar proximal tibial fracture [21]. In the ORIF group, bone graft was used almost twice as often, in 22 versus 12 patients. There were significantly more cases of sagittal malalignment in the LISS group than in the group treated with two plates, in 14.6% versus 2.3% of patients. At the end of the 2nd year of surgery, the results of the two groups were similar on the HSS rating scale. Regarding the choice of using one pre-contoured, laterally applied angle-stable plate (LCP) or two conventional plates, contemporary studies have found a lower rate of postoperative malalignment and better stability when using

two conventionally placed plates [22]. Another author found that the use of polyaxial plates facilitated the precise placement of screws in the periarticular zones and prevented the risk of varus collapse of the short proximal segment [23].

Concerning the use of the MIPPO technique with pre-contoured LCP-plates, there are published data on various complications, such as plate-screw breakdown in up to 18% of cases, unsatisfactory fracture reduction in up to 23% , the need of the implant removal in up to 30%, and skin irritation with superficial infection in up to 12% of cases [24, 25]. Regardless of the potential complications with conventional plates, locking plates represent a cutting-edge solution to the surgical problem associated with unstable tibial fractures, allowing sufficient biomechanical stability, due to the pre-contoured profile, and being highly suitable for elderly with severe osteoporosis [26, 27]. The MIO (minimally invasive osteosynthesis) technique and its variations - MIPPO TARPO and LISS-instrumentation - are associated with less soft tissue damage, respectively minimal blood loss, friendly to the periosteal blood supply [7,28]. The instrumentation for insertion requires a small surgical lateral approach, though the risk of infectious complications remains high, and it could compromise subsequent knee arthroplasty replacement [29]. Another possible complication associated with the use of titanium implants is the so-called "cold welding", which makes their removal extremely difficult and traumatic. Last but not least, the relatively high cost of titanium pre-contoured LCP plates is another matter of concern. There are no clinical studies in the current literature comparing the results of using conventional versus locking plates for the treatment of low-energy unicondylar fractures with Schatzker types I-III. There is also a lack of consensus on the best method of fixation, as well as on the optimal osteosynthetic instrumentation or filter for osteoplasty [30].

## 2. Extra-articular fractures

Current management of unstable extraarticular fractures of the proximal tibia poses several challenges in the choice of treatment approach. Because of the short proximal fragment, treatment by closed reduction and cast immobilization does not allow sufficient control of the achieved satisfactory limb alignment. That is confirmed by the disproportionately high incidence of unsatisfactory varus-type

deformity followed by the CRIF - conservative treatment.

Intramedullary tibial nailing is a standard choice for fractures with a long proximal segment and preserved soft tissue coverage. The “pollar screw” technique prevents the apex-anterior malalignment of the limb. Widening of the IM canal using the IMN technique with intramedullary canal reaming may further damage the already affected bone perfusion in

the fractured zone [15]. The IMN technique can be used to stabilize fractures of the proximal and distal third of the tibia but is accompanied by a high incidence of malunion. Although there are lots of variations in fracture patterns and operative approaches, most extra-articular fractures of the proximal third of the tibia can be successfully operated after a thorough evaluation of the skin condition, the fracture personality and the fracture stability (**Figure 2**).



**Figure. 2.** Extra-articular PNTF with soft tissue injury according to AO/OTA classification 41.A2; 42 B3a; 42

On the contrary to successful intramedullary fixation of diaphyseal tibial fractures, a high incidence of malalignment - valgus and varus angulation, apex-anterior angulation, posterior translation and malrotation - has been reported in the current literature, when IMN is applied for proximal meta-diaphyseal tibial fractures. Several different reduction and fixation techniques with different approaches and entry points, for IM nailing techniques have been used to minimize the described complications [15]. In conclusion, careful placement of an intramedullary nail that has a greater proximal curvature, the so-called "Herzog's bend", results in excellent final clinical outcomes and has the features of a low-risk treatment approach.

Nevertheless, the ORIF technique is the gold standard, thou associated with frequent soft tissue complications. On the contrary external fixation remains a treatment option for both open and closed fractures. Inadequate fracture healing in terms of delayed union, malunion and infections along the screw course are frequent complications. The multifragmentary high-energy, extra-articular metadiaphyseal tibial fractures with compromised soft tissue had significant fragment dislocation. The complex fracture models had severely injured local periosteal blood supply and disruption of both periosteal and endosteal vessels. Additionally, even minimally invasive surgical intervention inflicts significant iatrogenic trauma to the soft tissue envelope at the fracture site. Internal fracture plating in terms of ORIF or MIPPO-

techniques is an appropriate surgical technique but in the presence of preserved soft tissue coverage. In comminuted fractures, the lateral plate is combined with medial external fixation. In cases with open or closed soft tissue injuries, plates are placed with extreme caution or after soft tissue envelope revascularization [26, 31].

## RESULTS

Lindvall et al. compared the results of treating extraarticular unstable proximal tibial fractures with an intramedullary nail or with percutaneous locking plates (MIPPO) and evaluated the effect of the techniques used on achieving and maintaining fracture repair [31]. Both techniques allow the application of indirect reposition with minimal additional dissection. After a 6-month follow-up of a series of twenty patients treated with the IM nailing technique, 60% had excellent results, 25% had good, and 15% had unsatisfactory results, with bone healing time between 12 and 18 weeks. [32]. The use of MIPPO allows placement without significant incisions and soft tissue damage and reduces the risk of subsequent complications, infection and nonunion. The results of both methods show a statistically significant lack of loss of final reduction and confirm the stability of both types of osteosynthesis constructs. Neither method showed a statistically significant advantage. Apex-anterior deformity malalignment was the most common complication with both techniques. Additional open reduction techniques were necessary in IM nailing,

whereas implant removal was mandatory for MIPPO.

Berven et al. [33] compared the results of treating PTF type AO/OTA 41 by internal fixation methods with a locking plate or with a ring external fixator - Ilizarov type. Two groups of patients were treated, one group of 62 patients with PBF and another group of 68 patients with MIPPO. The union time was statistically significantly shorter ( $P = 0.041$ ) in the group treated with MIPPO. The incidence of non-union, malalignment, deep infection, thrombosis, re-operation, and posttraumatic osteoarthritis was comparable. Heterotopic ossification was statistically significantly more frequently ( $P = 0.013$ ) in the MIPPO group, and the external fixator's group had a statistically significantly higher incidence of superficial infection ( $P < 0.001$ ). The MIPPO with a single laterally placed LCP-PTP reduce soft tissue and infection complication rates as well as that of non-union due to preservation of periosteal blood supply. Though MIPPO is a more sparing operative technique, worse outcomes such as unsatisfactory alignment, secondary deformity and varus medial collapse were reported in the literature [33]. Due to the stress-distributing design of intramedullary implants, they redistribute the axial load equally along the bone and allow early mobilization and full WB, which is extremely important in the rehabilitation of elderly patients. When comparing IMN with external fixation, which is risky and not appropriate in osteoporotic bone changes, typical in elderly patients, it was found that loss of reduction and subsequent delayed fracture healing in the latter are not uncommon. On the other hand, these patients often have pre-existing traumatic injuries and have trouble complying with carrying bulky external constructs that make ambulation difficult and create difficulties for early rehabilitation.

Various external fixation instruments are suitable for the treatment of almost the entire spectrum of unstable metadiaphyseal tibial fractures. In selected cases of trauma, several types of external fixators are applied as a temporary external fixation device. Definitive external fixation is achieved with large, single-tube external fixation systems, the Ilizarov ring fixator, or various combinations of half-ring and single-tube systems known as hybrid fixators. The combination of limited internal osteosynthesis with a hybrid external fixator is a method that relies on indirect reposition

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techniques and percutaneous screw fixation of the intra-articular component of the fracture. The role of the external fixator is to maintain the correct axial and coronal alignment orientation of the fracture until it bone heals. It effectively support the comminuted medial cortical bone.

The main advantages of the method are related to its minimal invasiveness, the possibility of immediate active movement of the adjacent joints and partial loading of the injured limb. In the literature, the analysis of the treatment outcomes of a series of 418 patients with proximal tibial fractures treated with LCP plates compared to those treated with ORIF and MIO HF, infections and wound complications were reported with an incidence of 8% despite the low invasiveness of the MIPPO technique. That complication rate is lower than that of the ORIF series, but higher than that reported in the MIO HF series at 2.3%. There was also a higher malposition rate of 15.1% in the MIPPO series compared with the MIO HF series, with comparable functional outcomes [14]. Comparative analysis of the final functional outcomes of the series of 1280 patients treated with the three different techniques described in the literature shows that the MIO HF technique is superior to ORIF with conventional plates and comparable to the MIPPO technique with LCP plates.

In patients with proximal tibial fractures treated with hybrid fixator alone, the proportions of infectious complications of cases with arthrodesis and osteoarthritic changes were the lowest when compared with the surgical techniques discussed above. Malalignment rates in the entire group did not exceed 5% and were comparable to the other surgical methods. The comparative analysis of the results of the treatment of 980 distal tibial fractures showed that, in terms of functional recovery, the method using a hybrid fixator was superior to ORIF and the staged approach, and was comparable to the results of patients treated with MIO HF [14].

The reported rate of deep infections was significantly lower than ORIF, lower than that of patients treated with the staged approach, and comparable to that of patients treated with MIO HF.

The method offers a solution to the problem of deep infections in the treatment of pilon fractures. The overall rate of deep infections was lowest with the MIO HF technique, not

exceeding 5% in any reported series. The main disadvantage of MIO HF is related to pin-track inflammation in about 20% of cases, and it was mostly low-grade [14, 19]. The use of minimally invasive osteosynthesis techniques and an Ilizarov-type ring fixator has been recommended as a surgical option to minimize complications from the use of ORIF, especially in patients with multifragmentary tibial fractures of the AO/OTA C type. Although minimally invasive indirect reduction is usually associated with insufficient anatomic alignment of the intra-articular component, good functional results have been achieved by using this approach. Pirani et al. compared the use of a ring fixator combined with percutaneous screw application (hybrid fixation) to standard technique (ORIF) in patients with open or closed tibial plateau fractures of Schatzker type V-VI [32]. Outcomes of the two groups with a total of 66 patients were measured using generally accepted rating scales (WOMAC, HSS, SF-36) two years after surgery. Seven, or 18%, of the 40 patients in the ORIF group had deep infection, and patients in the hybrid fixation group had a lower risk of unplanned reoperation [32].

In a more recent study, hybrid definitive EF was found to be the most soft tissue sparing technique, with comparable final results to internal plate fixation [10]. Other authors, after a comparative analysis of the outcomes of single-stage hybrid EF and staged treatment with double plate internal fixation, reported a lower rate of deep infections with a slightly higher rate of superficial infections and a relatively higher rate of poor bone healing and posttraumatic arthritis, associated with hybrid external fixation [10, 34].

#### **NEW TREATMENT MODALITIES**

The novel surgical method – locked externalized plate stabilization was later termed supercutaneous stabilization and it was applied for the treatment of Gustilo type II and IIIA open fractures, nonunions and deep bone infections [6]. Though the preliminary clinical results are favorable, a few experimental studies have discussed the biomechanics of locked externalized plating based on FEA modeling and just one study has been reported to clarify the biomechanical issues related to the size and magnitude of the fracture defect (gap), to the distance between the bone and the plate (offset), and to the values of the parameters allowing to

achieve a state of relative stability combined with early partial loading of the limb [10-12]. Recently, the use of externally placed locking plates as a surgical method in selected patients with unstable fractures of the tibial meta-diaphysis, has been increasingly reported in the current literature [2, 6, 10, 34]. Super cutaneous fracture fixation is still a new and controversial but not unusual surgical method for precisely indicated (high-energy) multifragmentary tibial fractures with severe soft tissue injury [35-38]. A similar, to the externalized locked plating, surgical technique for one-staged fracture treatment for the first time was reported in Poland, several decades ago by using an external splinting device – The Zespol System [39]. Initially, the technique of externalized locked plating was introduced in the treatment of open fractures and nonunions, septic arthritis, and as an adjunctive external stabilization in bone lengthening by distraction osteogenesis [3, 6, 35, 36]. Locked external plating (LEP), locked externalized fracture stabilization or Single stage Externalized Locked Plating (SSELP) are terms that describe the LCP plate application as a monolateral external splinting device for definitive surgical treatment of unstable meta-diaphyseal tibial fractures [37,38]. These fractures, due to their short proximal metaphyseal segment spanning the well-blooded tibial condylar zone and - combined with significant soft tissue trauma - are good candidates for external locked plate fixation. In the area of the anteromedial aspect of the tibia, the subcutaneous tissue is thin, and there are no vital vessels, nerves, or muscles that would be iatrogenic injured after the previously performed indirect closed fracture repair. When closed reduction is not possible, minimal fenestration holes with/or stab incisions are used. Thus, the plate functions on the principle of a buttressing monolateral external splint with attachment to the bone by angularly stable locking screws penetrating both cortices of the underlying tibia whenever possible and locking to corresponding holes in the metal splint. This facilitates the early patient mobilization and ambulation, makes the patient handling easy and simple. The maintenance of bone-penetrating screw hygiene and creates an aesthetically more acceptable design for the patient compared to the wide range of traditional external fixators systems, such as monolateral, hybrid, ring, or hexapod designs [2]. Definitive surgery is performed using the LISS fixator, which is an anatomically

contoured locking metaphyseal plate, the LCP, used as an external fixator and originally designed for the operative treatment of

supracondylar femoral fractures – A One-Stage Locked Externalized Plating (**Figure 3**), [38].



**Figure 3.** Locked External Plate Stabilization (LEPS) and after externalized plate removal.

The locked external plate stabilization (LEPS) with angle-stabled plates is an effective method for a safe external biological stabilization called "biological plating" by Peren and Ganz in the treatment of primary complicated multifragmentary UTF. Through the application of LEPS, uneventful natural (secondary) bone

healing is achieved with the formation of a solid callus within the accepted standard time frame.

The novel technique - LEPS is comfortable for primary wound care and faster patient quality of life recovery, facilitating smooth return to a normal daily lifestyle (**figure 4**).



**Figure 4.** Excellent clinical and functional results with 60 months follow up.

The use of LCP plates is particularly suitable for the treatment of elderly patients with osteoporosis, due to minimal trauma of the SSELP fixation and the expected optimal stability of fixation. However, the low complication rates and excellent functional results in the adjacent knee and ankle joints are still insufficient convincing evidence for the widespread acceptance and application of the method. Recently, many authors have presented clinical results demonstrating successful bone healing within generally accepted time ranges in the treatment of unstable meta-diaphyseal, proximal and distal, tibial fractures [2, 35-40]. Further experimental studies and randomized multicentric clinical trials with larger series of patients are necessary to pave the way of its use in clinical practice.

## CONCLUSION

Anatomically precontoured locking plates have been successfully used in the treatment of tibial plateau fractures and multifragmentary

fractures in the metadiaphyseal transition zone. The locking plate can be positioned proximal-cephalad or distal-caudal, submuscular with a minimally invasive technique thus functions as an "internal-external fixator". Advantages of the locking plate include preservation of blood supply and better resistance to bending and twisting forces compared to conventional non-locking plate systems. Factory precontouring saves time and does not require pre-bending of the plate during handling.

Intramedullary tibial nailing is a standard choice for fractures with a long proximal segment and preserved soft tissue coverage. The "pollar screw" technique prevents the apex-anterior malalignment of the limb. In conclusion a careful placement of an intramedullary nail that has a greater proximal curvature result in excellent final clinical outcomes and has the features of a low-risk treatment approach.

The supracutaneous locked plating – a novel technique called **Single-Stage Externalized**



**Locked Plating**, may provide a well-performing and easily applicable surgical instrumentation, if compared to the standard monolateral external fixators. The most specific characteristic is the small and convenient profile and shape of SSEL. From an aesthetic and economic point of view, Single-Stage Externalized Locked Plating is more acceptable for multiple trauma patients with complex, high-energy tibial fractures, in terms of low profile, comfortable design and simplicity of the system, which makes it a promising surgical option. The advantages of this approach are related to the optimal angular stability of the plate-screw interface, the ductility of the construct, a save, fast and easy technique with low learning curve, and minimal inflammatory complications compared with traditional external fixation techniques.

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