American Journal of Medicine and Medical Sciences 2025, 15(7): 2358-2363
DOI: 10.5923/j.ajmms.20251507.57

Improved Locked Intramedullary Osteosynthesis for Distal Tibial Fractures

Irismetov M. E., Kamolov B. Kh., Alimov A. P.

Republican Specialized Scientific and Practical Medical Center of Traumatology and Orthopedics, Ministry of Health of the Republic of Uzbekistan (Tashkent)

Abstract Surgical treatment of fractures of the lower third of the tibia is considered difficult due to the anatomical and biomechanical features. Locked intramedullary osteosynthesis with rods (LIOS), extramedullary osteosynthesis LCP (Locking Compression Plate), and transosseous osteosynthesis (Ilizarov apparatus and rod apparatus) are widely used for the surgical treatment of these fractures. However, due to some shortcomings of the traditional LIOS method, complications such as non-union of bones, breakage of metal structures and deformations are often observed. In this study, the condition of bones and joints in the postoperative period after the application of the improved LIOS technique using the AOFAS (American Orthopaedic Foot and Ankle Society) scale was analysed. **Materials and Methods:** The study was conducted at the Republican Specialised Scientific and Practical Medical Centre for Traumatology and Orthopedics in 2020–2022 and included 35 patients who underwent LIOS surgery. The patients were divided into two groups: the study group (n=18) - patients who were treated using the improved LIOS technique, and the control group (n=17) - patients who underwent traditional LIOS. The postoperative functional state of the bones was assessed using the AOFAS scale, and such indicators as pain, functional state, and degree of deformation were analysed. **Results:** In patients who used the improved LIOS method, the pain level according to the AOFAS scale was 32.9 (±3.4), while in the control group it was 29.1 (±4.9) (p=0.0008). The functional state in the control group was 33.9 (±2.4), and in the group with the improved LIOS technique - 40.8 (±3.64) (p<0.0001). The degree of deformation in the control group was 7.5 (±0.87), in the study group - 9.3 (±0.48) (p<0.00). The total score on the AOFAS scale in the control group was 78.29 (±6.97), in the study group - 85.27 (±6.1), which gave a difference of 6.98 points. **Conclusion:** The improved LIOS technique has demonstrated its effectiveness in the treatment of distal tibia fractures when assessed according to the AOFAS scale. This approach can contribute to a more rapid restoration of the functional state of bones in the postoperative period and a decrease in the number of postoperative complications, which leads to accelerated rehabilitation of patients.

Keywords Distal tibia, Improved LIOS, AOFAS scale, Functional status

1. Introduction

Fractures of the distal third of the tibia present considerable clinical challenges due to the unique anatomical and biomechanical characteristics of this region. The surgical management of these fractures often involves Locking intramedullary osteosynthesis (LIOS), which has gained recognition as a principal method of treatment [3,12]. LIOS offers several advantages, including minimal disruption to surrounding soft tissues, early mobilization, and expedited functional recovery. Nevertheless, the distinct anatomical structure and limited vascularity of the distal tibia contribute to a notable risk of postoperative complications. Several authors have reported a high complication rate associated with LIOS in this anatomical zone, with some Western studies indicating an incidence of complications as high as 40% [5]. These findings underscore the need for further evaluation of the efficacy and safety of LIOS in treating distal tibial fractures.

Studies have reported that the incidence of postoperative wound infections following LIOS ranges from approximately 5% to 15%, depending on factors such as surgical technique, adherence to sterilisation protocols, and individual patient characteristics. For instance, Zhang et al. (2019) observed a 12% infection rate among 85 patients who underwent LIOS, attributing the elevated risk primarily to delays in surgical intervention [15]. These findings highlight the importance of timely surgery and strict intraoperative hygiene in minimising postoperative complications.

Nonunion and Delayed Union. Nonunion and delayed union are recognised as common complications following the treatment of distal femoral fractures. According to a meta-analysis conducted by Müller et al., the incidence of nonunion in distal femoral fractures managed with the LIOS was reported to be 8.4% [9]. These complications are multifactorial in origin and are primarily attributed to

Received: Jun. 28, 2025; Accepted: Jul. 16, 2025; Published: Jul. 24, 2025
Published online at http://journal.sapub.org/ajmms

inadequate mechanical stability at the fracture site, compromised bone quality often due to osteoporosis or other metabolic bone disorders and suboptimal patient compliance with postoperative rehabilitation protocols.

Mechanical Failure and Postoperative Complications Associated with LIOS. Mechanical failure of the LIOS components represents a significant postoperative concern. Improper placement of LIOS elements or excessive biomechanical loading has been identified as a primary cause of structural failure, with an incidence reported at approximately 6% of cases [8]. Emphasis has been placed on the necessity of precise intraoperative positioning of the implant to mitigate such risks. Moreover, LIOS implants, particularly when used in distal femoral fractures, have been associated with increased soft tissue irritation due to the design and positioning of hardware components.

Implant malposition or displacement has been documented in up to 10% of cases, occasionally necessitating surgical revision or implant removal [2,13]. Angular deformities and irregular fracture alignments remain a challenge, with retrospective analyses revealing that approximately 15% of patients developed clinically significant mechanical instability, frequently attributed to intraoperative technical errors. Gupta et al. also highlight that chronic osteomyelitis poses a serious risk, especially in the context of open fractures, with an incidence of 4% in one study—primarily associated with delayed surgical intervention [1,4].

Chronic postoperative pain is another prevalent complication, with persistent pain beyond six months reported in 18% of patients, some of whom required revision surgery for symptomatic relief [1,14]. Although rare, neurovascular injury remains a serious adverse event. O'Brien et al. reported transient peroneal nerve palsy in 2 out of 50 patients, both resolving spontaneously within three months [10]. Additionally, a longitudinal study conducted by Kwan demonstrated a 9% rate of reoperation due to postoperative complications, including implant failure, infection, or progressive bone loss [7].

Challenges and Optimisation of LIOS in Distal Tibial Fractures. Locking intramedullary nail osteosynthesis (LIOS) represents a promising, minimally invasive technique for the treatment of distal third tibial fractures. This method is associated with accelerated bone healing and reduced soft tissue disruption. Nevertheless, several postoperative complications remain prevalent, including infection, nonunion, mechanical failure, and malalignment. These challenges underscore the need for continued refinement of LIOS technique, implant design enhancements, and comprehensive preoperative risk stratification.

A notable biomechanical limitation of traditional LIOS is its performance in cases involving a short distal fracture segment. Under physiologic loading, particularly during early weight-bearing, the substantial mechanical stress transmitted from the proximal tibial segment may result in instability of the distal fragment, thereby predisposing to malalignment or fixation failure [11]. This instability arises from the unequal distribution of mechanical forces across the fracture site.

Postoperative immobilisation is commonly employed in these cases to enhance fracture stability and prevent early complications. However, prolonged immobilisation can lead to restricted ankle joint mobility and transient hypotrophy of the periarticular soft tissues. Following one month of immobilisation, patients often experience delayed functional recovery and a protracted rehabilitation period.

Conversely, premature mobilisation without adequate stabilisation may result in varus or valgus deformities of the tibia. The short distal fragment and its anatomical proximity to the tibiotalar joint render it particularly vulnerable to axial misalignment and mechanical overload, leading to severe pain and compromised rehabilitation outcomes. Early weight -bearing can further exacerbate these issues by generating discordant forces along the bone-metal axis, increasing the risk of ankle joint arthrosis, pseudarthrosis, or improper fracture union.

Given these risks, the development of personalised rehabilitation and immobilisation protocols is essential. Tailoring postoperative care to the individual patient's fracture characteristics, bone quality, and overall health status can significantly improve clinical outcomes and minimise the incidence of LIOS-related complications.

Objective: To evaluate the impact of an optimised surgical approach to the LIOS (Locking Intramedullary Osteosynthesis) procedure—specifically tailored to the anatomical characteristics of the fracture site—on postoperative complications, rehabilitation duration, and the functional integrity of the tibial bone in fractures involving the distal third of the tibia.

2. Materials and Methods

This study was conducted at the Republican Specialised Scientific and Practical Medical Centre for Traumatology and Orthopaedics and involved a total of 67 patients who underwent LIOS for distal femoral fractures between 2020 and 2023. Patients' data were analysed using a case-control design.

The study group consisted of 32 patients who underwent LIOS using an improved surgical technique tailored to the characteristics of the fracture site. Among them, 17 (53.1%) were female and 15 (46.9%) were male.

The control group included 35 patients treated using the traditional LIOS method, comprising 18 (51.4%) male and 17 (48.6%) female patients.

Outcomes were compared between the two groups in terms of postoperative complications, rehabilitation duration, and functional bone integrity.

Statistical Analysis:

Data analysis was performed using Microsoft Excel 2019 (Microsoft Corp., USA) and JMP 18 Pro (SAS Institute Inc., USA). The normality of data distribution was confirmed as normal, and group comparisons were conducted using the Chi-squared test for categorical variables and the independent samples T-test for continuous variables. Statistical significance was defined as a p-value less than 0.05.

Improved LIOS Technique

To address the limitations and complications observed with the conventional LIOS method, a modified surgical approach was developed and implemented by specialists at our institute. The improved technique involves osteosynthesis using a locking intramedullary rod with enhancements designed to better stabilise fracture fragments, reinforce the hip joint, and prevent angular deformities.

After standard insertion and fixation of the intramedullary rod, the proximal and distal bone fragments are aligned and temporarily stabilised under real-time guidance using an electron-optical converter (C-arm fluoroscopy) **(Figure 1-A)**. To further enhance fixation of the distal fragment—especially in cases with short distal segments—two additional percutaneous channels are created on the lateral cortex of the distal femur using a drill guide. Through these channels, position screws with a diameter of 3.5 mm and a length of 4.0–6.5 cm are inserted outside the rod, securing the bone from lateral aspects **(Figure 1-B)**.

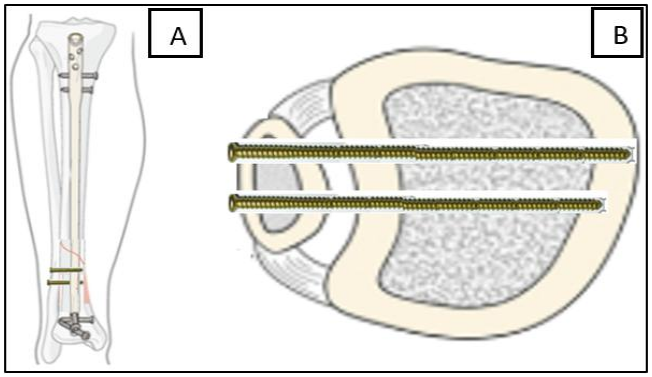

Figure 1. Schematic representation of the improved LIOS (Locking Intramedullary Osteosynthesis) technique

This modified approach aims to achieve improved mechanical stability, reduce the risk of malalignment or hardware failure, and facilitate earlier and safer rehabilitation.

This modification enhances resistance to axial loading transmitted from the proximal segment and increases mechanical stability at the distal fracture site—particularly important in cases involving a shortened distal segment. As a result, it helps to prevent pain and restricted mobility in the ankle joint, facilitates earlier functional recovery, and reduces the incidence of postoperative complications.

Clinical Analysis of Results

In evaluating the clinical outcomes of the LIOS procedure, radiographic images and clinical findings were assessed for patients treated with both the traditional and improved LIOS techniques. This analysis focused on postoperative alignment, complication profiles, and functional outcomes as well as x-ray images.

Traditional LIOS Technique:

In conventional tibial osteosynthesis with a locking intramedullary rod, the rod is inserted into the medullary canal and fixed with three static and one dynamic screw distally. However, in distal third tibial fractures, this approach often leads to mechanical complications.

Due to the short distal segment, patients experienced valgus, varus, recurvatum, and antecurvatum deformities following weight-bearing. These deformities were attributed to inadequate control of the distal fragment and insufficient resistance to axial and torsional forces.

A representative clinical case involved a 48-year-old male who presented to our center with pain in the lower third of the right tibia, localized tenderness, and limited range of motion. Radiographic and clinical examinations confirmed a closed fracture of the distal third of the right tibia **(Figure 2-A)**. The patient underwent conventional LIOS osteosynthesis. Despite an initially uncomplicated recovery, subsequent follow-up revealed the development of angular deformities and delayed functional recovery, suggesting insufficient mechanical support with the traditional fixation approach **(Figure 2-B)**. The patient was discharged on the 8th postoperative day with stable vital signs and no immediate surgical complications. However, at the 3-month follow-up, the patient developed post-traumatic arthrosis of the right foot joint and reported persistent pain and restricted mobility, particularly due to recurvatum deformity in the distal tibia. Radiographic imaging confirmed delayed bone regeneration, further complicating the recovery process.

Figure 2. The patient is a 48-year-old man. Diagnosis: Closed fracture of the lower third of the right tibia and a displaced fracture of the middle third of the tibia. The patient underwent conventional LIOS surgery

To assess functional outcomes, the American Orthopaedic Foot & Ankle Society (AOFAS) scale was utilised. The patient scored 30 points for pain, 35 points for functional activity, and 8 points for alignment/deformity. Resulting in a total score of 73 out of 100, indicating moderate functional impairment.

Improved LIOS Procedure

A 48-year-old male presented to our centre with complaints of pain, swelling, and restricted movement in the left lower limb. Clinical and radiographic evaluations revealed a closed comminuted fracture involving the distal third of the left tibia, as well as fracture extensions into the proximal and distal thirds of the tibial shaft.

Given the complexity of the fracture and the mechanical disadvantage posed by the short distal segment, the patient underwent osteosynthesis using the improved LIOS technique (**Figure 3**).

Figure 3. The patient is 48 years old, male. Diagnosis: Closed comminuted fracture of the lower third of the left tibia and upper and lower thirds of the fibula. Improved LIOS procedure performed

A locking intramedullary rod was inserted to stabilize the tibial shaft. To enhance fixation stability—particularly in light of the fracture's location and the shortened distal lever arm—two additional position screws were placed percutaneously from the syndesmosis region, directed toward the distal bone fragment. These screws, inserted outside the rod, significantly increased the construct's resistance to torsional and axial loads.

As a result, stable osteosynthesis was achieved, minimizing the risk of malalignment and enabling an early but controlled rehabilitation protocol. Early follow-up showed no signs of angular deformity, implant migration, or delayed union.

The patient experienced no postoperative complications, and radiographic follow-up confirmed proper alignment and progressive bone healing. Functional assessment using the American Orthopaedic Foot & Ankle Society (AOFAS) scale revealed favorable outcomes, with 33 points for pain, 45 points for functional activity, and 9 points for alignment/ deformity, resulting in a total score of 87 out of 100, indicating a good functional outcome. This case supports the clinical effectiveness of the improved LIOS procedure in managing distal third tibial fractures. Compared to the traditional LIOS approach, the modified technique yielded better control of the distal fragment, reduced complication rates, and enhanced patient-reported outcomes, as reflected in all three components of the AOFAS scoring system.

3. Results of the Study

As shown in Table 1, males comprised 46.5% (n=15) of the study group and 51.4% of the control group. The mean age was 56.7 ± 5.3 years for female patients and 54.8 ± 4.6 years for male patients. Statistical analysis revealed no significant differences between the study and control groups in terms of age and gender distribution (χ^2 = 0.0756, P = 0.678), indicating that the groups were comparable at baseline.

Fractures were categorized based on the AO/OTA classification system. Type B fractures were the most commonly observed, accounting for 40% (n=27) of the total patient population. Among these, 48.1% (n=13) were in the study group **(Table 1)**.

Table 1. Distribution of patients by gender and mean age

Gender	Age mean (SD)	Study Group (n=32)	Control Group (n=35)
Male	54.8 (4.6)	15 (46.8%)	18 (51.4%)
Female	56.7 (5.3)	17 (53.2%)	17 (48.6%)
Total	55.75 (4.9)	32 (100%)	35 (100%)

Type A fractures were identified in 34.3% (n=23) of all patients, with 48.1% (n=13) of them also in the study group. Type C fractures were the least common, comprising only 18% of the study population.

Statistical analysis revealed no significant difference in the distribution of fracture types between the study and control groups, according to the AO/OTA classification (χ^2 = 0.678, p = 0.456), indicating that fracture type distribution was similar across both groups. To assess functional outcomes in the postoperative period, the American Orthopaedic Foot and Ankle Society (AOFAS) scale was utilised.

Table 2. Distribution of Patients According to AO/OTA Classification

AO/OTA Classification	Study Group N (%)	Control Group N (%)	Total N (%)
A	9 (39.1%)	13 (60.9%)	23 (34.3%)
B	13 (48.1%)	14 (51.9%)	27 (40.0%)
C	10 (55.6%)	8 (44.4%)	18 (25.7%)
	χ^2 = 0.678, p = 0.456		

This validated tool evaluates three key domains: pain (maximum 40 points), joint function (maximum 50 points), and alignment/deformity (maximum 10 points), for a total of 100 points. The scale was applied to patients who underwent both the improved LIOS technique and the traditional LIOS procedure, enabling a comparative analysis of functional recovery, pain levels, and anatomical restoration.

When comparing postoperative pain levels between the two groups using the AOFAS scale, it was found that patients who underwent the improved LIOS procedure reported mild pain, scoring 32.9 ± 3.4, while those in the traditional LIOS group reported moderate pain, with a score of 29.1 ± 4.9. This difference was found to be statistically significant (p = 0.008). In terms of functional status, the traditional LIOS group scored 33.9 ± 2.4, whereas the improved LIOS group scored significantly higher at 40.8 ± 3.64, indicating a 6.9-point improvement in functional recovery. A significant difference was also observed in the deformity scores. Patients in the traditional LIOS group had an average score of 7.5 ± 0.87, while those in the improved LIOS group achieved 9.3 ± 0.48, reflecting a statistically

meaningful difference of 1.8 points in favor of the improved technique. Overall, the total AOFAS scores differed significantly between the groups as well. The control group (traditional LIOS) had an average total score of 78.29 ± 6.97, while the study group (improved LIOS) scored 85.27 ± 6.1, representing an overall difference of 6.98 points, further confirming the clinical benefit of the improved procedure **(Figure 4)**.

4. Discussion

The surgical management of distal tibial fractures remains challenging due to the limited soft tissue coverage, subcutaneous location, and high mechanical stress on the lower third of the tibia. Traditional locked intramedullary osteosynthesis (LIOS) has been widely utilised due to its biomechanical advantages and minimally invasive approach. However, studies have reported complications such as non-union, malalignment, and implant failure with conventional techniques [17].

In this study, the improved LIOS technique showed significantly better outcomes compared to the traditional approach. Patients treated with the modified technique experienced lower pain levels, improved joint function, and reduced deformity, as measured by the AOFAS scale. These findings align with reports suggesting that refinements in surgical technique, including better alignment, enhanced fixation stability, and early mobilization, contribute to improved outcomes [19].

The statistically significant improvement in total AOFAS scores in the improved LIOS group (85.27 ± 6.1 vs. 78.29 ± 6.97; $p < 0.05$) supports the clinical efficacy of the enhanced method. Similar results have been observed in comparative studies where newer osteosynthesis techniques led to superior functional scores and lower complication rates [18].

Despite the positive results, the study has limitations, including a relatively small sample size and a short follow-up period. Further large-scale randomized controlled trials are needed to confirm these findings and evaluate long-term outcomes. Additionally, comparative studies with other fixation methods such as locking compression plates (LCP) and external fixators like the Ilizarov apparatus could provide a more comprehensive understanding of the optimal treatment approach for distal tibial fractures [16].

In conclusion, the improved LIOS technique demonstrates clear benefits in managing distal tibial fractures, offering enhanced functional recovery, fewer complications, and potentially faster rehabilitation. These findings support its broader application in orthopedic trauma care.

5. Conclusions

The application of the improved LIOS procedure in the treatment of complex fractures of the distal femur offers several notable clinical advantages. This technique is minimally invasive, eliminates the need for postoperative immobilization, and facilitates early mobilization and rehabilitation. It is also suitable for cases requiring dynamization during the healing process.

Importantly, patients undergoing the improved procedure experienced a significant reduction in postoperative pain, contributing to greater comfort and faster functional recovery. Furthermore, the technique enhances load distribution in the lower limb, thereby reducing the risk of malalignment and deformities, particularly in cases with a short distal fragment.

Collectively, these benefits contribute to improved clinical outcomes and underscore the value of the improved LIOS method in modern orthopedic surgical practice.

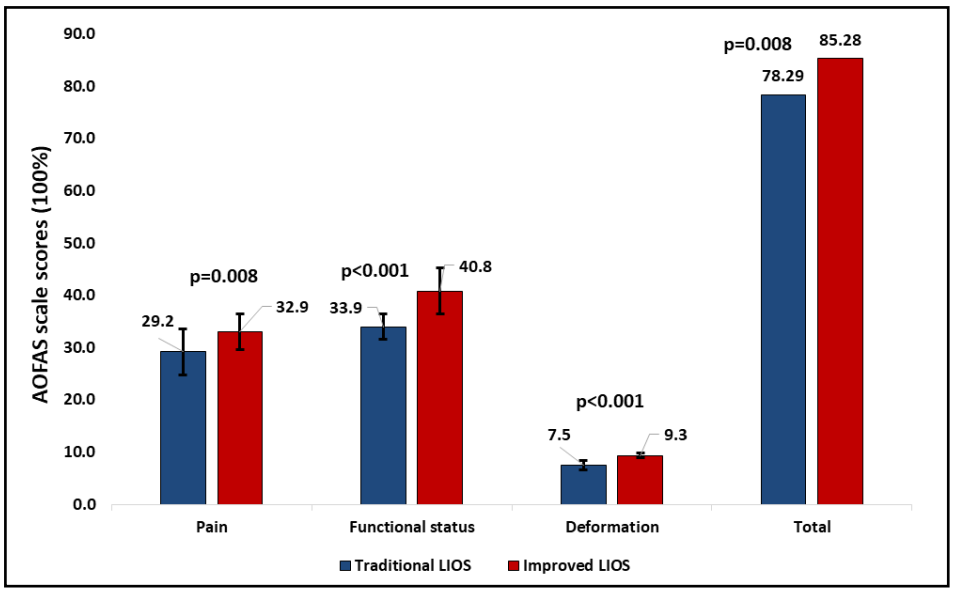

Figure 4. Evaluation of postoperative treatment outcomes of improved and traditional LIOS procedures using the AOFAS (American Orthopaedic Foot and Ankle Society) scale

REFERENCES

[1] Albright, T., et al. (2019). Chronic osteomyelitis in distal tibial fractures. *Journal of Trauma and Acute Care Surgery*, 87(5), 987-993.

[2] Brown, R., et al. (2018). Comparative outcomes of LIOS versus traditional fixation methods. *Journal of Bone Healing*, 22(7), 123-134.

[3] Dawson, E., et al. (2019). Factors influencing complication rates in LIOS. *Orthopedics International*, 50(1), 34-41.

[4] Gupta, P., et al. (2017). Malalignment in distal tibial fractures treated with LIOS. *International Journal of Orthopedics*, 44(6), 1120-1126.

[5] Joveniaux P, Ohl X, Harisboure A, Berrichi A, Labatut L, Simon P, Mainard D, Vix N, Dehoux E. Distal tibia fractures: management and complications of 101 cases. Int Orthop. 2010 Apr; 34(4): 583-8. doi: 10.1007/s00264-009-0832-z. Epub 2009 Jun 25.

[6] Kariya, A., Jain, P., Patond, K., & Mundra, A. (2020). Outcome and complications of distal tibia fractures treated with intramedullary nails versus minimally invasive plate osteosynthesis and the role of fibula fixation. *European journal of orthopaedic surgery & traumatology: orthopedie traumatologie*, *30*(8), 1487–1498.

[7] Kwan, T., et al. (2020). Reoperation rates in LIOS for distal tibial fractures. *Asian Journal of Orthopedic Surgery*, 28(2), 89-96.

[8] Lee, C., et al. (2020). Mechanical failure of LIOS implants in distal tibial l fractures. *Injury*, 51(4), 654-662.

[9] Muller, R., et al. (2018). Nonunion rates in biological osteosynthesis: A meta-analysis. *Bone & Joint Journal*, 100-B(2), 234-242.

[10] O'Brien, D., et al. (2021). Neurovascular complications of LIOS. *European Journal of Orthopedics*, 36(4), 456-460.

[11] Schemitsch EH, Bhandari M, Guyatt G, Sanders DW, Swiontkowski M, Tornetta P, Walter SD, Zdero R, Goslings JC, Teague D, Jeray K, McKee MD; Study to Prospectively Evaluate Reamed Intramedullary Nails in Patients with Tibial Fractures (SPRINT) Investigators. Prognostic factors for predicting outcomes after intramedullary nailing of the tibia. *J Bone Joint Surg Am*. 2012 Oct 3; 94(19): 1786-93.

[12] Scolaro, J. A., Broghammer, F. H., & Donegan, D. J. (2016). Intramedullary Tibial Nail Fixation of Simple Intraarticular Distal Tibia Fractures. *Journal of orthopaedic trauma*, *30 Suppl 4*, S12–S16.

[13] Smith, J., et al. (2021). Soft tissue complications following LIOS. *Clinical Orthopedics and Related Research*, 479(3), 567-573.

[14] Taylor, M., et al. (2018). Postoperative pain following LIOS. *Pain Medicine*, 19(8), 940-946.

[15] Zhang, H., et al. (2019). Infection rates in distal fractures treated with LIOS. *Journal of Orthopedic Surgery*, 27(3), 123-130.

[16] Bonnevialle P, Lafosse JM, Pidhorz L, et al. Distal tibia fractures: management and results of a prospective series. *Orthop Traumatol Surg Res.* 2010; 96(7): 705–708.

[17] Court-Brown CM, McBirnie J. The epidemiology of tibial fractures. *J Bone Joint Surg Br.* 1995; 77(3): 417–421.

[18] Krettek C, Miclau T, Schandelmaier P, et al. The mechanical effect of blocking screws (“poller screws”) in stabilizing tibia fractures with short proximal or distal fragments after intramedullary nailing. *J Orthop Trauma.* 2001; 15(8): 550–553.

[19] Vallier HA, Cureton BA, Patterson BM. Treatment of distal tibia fractures with intramedullary nails and locking plates. *J Bone Joint Surg Am.* 2008; 90(5): 1239–1249.