BMC Surgery

RESEARCH

Open Access

Comparative analysis of the parapatellar and subpatellar approaches in reducing peripheral knee pain post-intramedullary tibial fracture surgery

Shaoyu Han[1†], Bingjun Cui[1†], Lang Wu[1], Chuangong Wang[1] and Zhixiang Chen[1,2*]

Abstract

Introduction Intramedullary tibial nailing is a standard treatment for tibial shaft fractures. Postoperative knee pain significantly impacts functional recovery; however, studies on this issue are limited. This study evaluated the effect of the parapatellar approach for intramedullary nailing on postoperative knee pain.

Materials and methods A total of 29 patients with tibial shaft fractures treated with intramedullary nails from March 2019 to January 2022 were divided into two groups based on the surgical approach: the semi-extended lateral parapatellar approach and the conventional subpatellar ligament split approach. Recorded metrics included operation time, intraoperative fluoroscopy count, intraoperative bleeding volume, Visual Analog Scale (VAS) scores for knee pain at 24 h, 72 h, 1 week, and 1 month postoperatively, fracture healing time and Lysholm knee functional scores at 12 months.

Results Both groups completed the operation without significant differences in operation time, intraoperative bleeding, fracture healing time, or intraoperative fluoroscopy ($P > 0.05$). The parapatellar group showed significantly better VAS scores for knee pain at 24 h, 72 h, and 1 week postoperatively compared to the control group ($P < 0.05$), with no significant difference at 1 month. After 12 months, Lysholm scores indicated no significant differences in knee support, locking, and swelling ($P > 0.05$); however, the parapatellar group showed significant improvements in lameness, instability, stair climbing, squatting, and pain ($P < 0.05$). Overall, the parapatellar group outperformed the control group ($P = 0.01$). Additionally, long-term follow-up revealed potential advantages of the parapatellar approach in improving long-term functional outcomes.

Conclusions Using the parapatellar approach for tibial intramedullary nailing avoids splitting the patellar ligament and entering the joint cavity, minimizing knee joint impact and effectively reducing postoperative knee pain, with potential benefits in long-term functional recovery.

Keywords Tibial fracture, Parapatellar approach, Tibial intramedullary nail, Knee pain

[†]Shaoyu Han and Bingjun Cui contributed equally to this work.

*Correspondence:
Zhixiang Chen
chenzhixiang10270@126.com

[1]Trauma Center, Huai'an Hospital Affifiliated to Yangzhou University(The Fifth People's Hospital of Huai'an City), Huai'an 223001, Jiangsu Province, China
[2]Department of Orthopedic Surgery, Northern Jiangsu People's Hospital Affiliated to Yangzhou University, Yangzhou 225001, Jiangsu Province, China

Introduction

Tibial shaft fractures are among the most common long bone fractures, accounting for approximately 10–15% of all long bone fractures. With the increasing global population and the rise in high-energy trauma incidents, such as motor vehicle accidents and falls from height, the incidence of these fractures has been on the rise. Recent data from a major trauma center in the United States reported an incidence of over 50,000 tibial shaft fractures annually, highlighting the significant burden on healthcare systems [1]. The clinical impact of these fractures is significant, as they can lead to prolonged hospital stays, substantial rehabilitation, and long-term disability if not managed effectively. The economic burden is also considerable, with direct medical costs and indirect costs due to lost productivity amounting to billions of dollars each year. Intramedullary nailing(IMN) is generally considered the gold standard [2–4] for treating tibial shaft fractures. However, recent studies have shown that up to 70% of patients experience some degree of knee pain, with approximately 30–40% reporting chronic pain lasting more than six months [5–8]. This pain can severely impair functional recovery and quality of life, highlighting the importance of optimizing surgical techniques to minimize its occurrence [9, 10].

In the context of geriatric orthopedic conditions, osteoporosis significantly increases the risk of fractures, including those of the tibia. Characterized by reduced bone density and compromised bone strength, osteoporosis makes elderly individuals more susceptible to fractures from minor falls or trauma [11]. According to the International Osteoporosis Foundation, osteoporosis is responsible for over 8.9 million fractures annually worldwide, with a fracture occurring every three seconds [12]. Previous research from Ronghua Zhang's lab has emphasized the importance of considering bone quality and density when selecting surgical techniques and implants for patients with osteoporosis, highlighting the need for tailored surgical approaches in this patient demographic [13].

Postoperative peripheral knee pain, particularly anterior knee pain, significantly impacts functional outcomes and can arise from various factors, including local anatomical issues, surgical trauma, and postoperative muscle weakness [4–14]. The development of specialized surgical tools, such as the V-blade tip needle scalpel, reflects a broader trend towards more precise and efficient surgical techniques. The V-blade tip needle scalpel represents a significant advancement in orthopedic surgical instruments, designed to improve accuracy and efficiency during procedures like ultrasonography-guided percutaneous A1 pulley release [15, 16]. For procedures such as tibial intramedullary nailing, traditional approaches include subpatellar, suprapatellar, and parapatellar methods. The subpatellar approach, which involves splitting the patellar ligament and requires extreme knee flexion, can potentially damage the patellar ligament and the infrapatellar nerve, resulting in postoperative anterior knee pain [17–21]. This approach allows for direct visualization and manipulation of the fracture site, which can be advantageous in certain scenarios. However, it is associated with higher rates of anterior knee pain due to potential disruption of the patellar ligament and increased joint pressure [22, 23]. In recent years, the promotion and use of patellar approach devices have facilitated the adoption of the patellar approach for intramedullary nailing. This method allows for easier fracture end traction and closed reduction by extending the intramedullary nail through the knee joint. However, it can increase patellofemoral joint pressure, potentially leading to postoperative anterior knee pain [24–26].

Evidence suggests that the lateral parapatellar approach can decrease iatrogenic soft-tissue damage compared to traditional methods. For instance, robotic-assisted total knee arthroplasty, which utilizes a similar approach, has been shown to result in less iatrogenic soft-tissue damage compared to manual approaches [27, 28]. Although this evidence is from knee arthroplasty, it supports the potential benefits of the lateral parapatellar approach in other surgical procedures, including IMN for tibial shaft fractures.

Moreover, the semiextended lateral parapatellar approach has been described as a novel technique that can reduce surgery time and minimize complications during tibial nail placement [29]. This approach also allows for better visualization and easier manipulation of the proximal tibia, which can lead to more accurate placement of the nail and improved functional outcomes [30]. While specific data on the lateral parapatellar approach in the context of tibial shaft fractures is not provided, the general principle that minimizing soft-tissue damage can lead to reduced pain is supported by the literature.

The lateral parapatellar approach appears to be a viable alternative for IMN of tibial shaft fractures, offering potential advantages in reducing periarticular pain and improving functional outcomes by minimizing iatrogenic soft-tissue damage. Further research and clinical trials are needed to fully evaluate its efficacy and safety compared to traditional methods. However, there are few research on this subject. This study will aid in the development of the effective nailing procedure for reducing the periarticular pain.

Materials and methods

The study is a retrospective study, has been approved by the Ethics Committee of Huai'an Hospital affiliated to Yangzhou University, with approval number KY-P-2022-015-01, and the study has been approved in written form.

This study retrospectively analyzed patients with tibial fractures who underwent intramedullary nailing at our hospital from March 2019 to January 2022. All patients provided written informed consent for the surgical procedures.

The study was retrospective in nature, and patients were not randomized. Instead, they were assigned to either the parapatellar or subpatellar approach group based on the surgical approach deemed most appropriate by the treating surgeon at the time of surgery. This decision was influenced by factors such as the specific fracture pattern, patient anatomy, and surgeon's experience.

Clinical data

Inclusion and exclusion criteria

Inclusion criteria: age ≥ 18 years; precise diagnosis; clear surgical indication; fracture not involving the articular surface; fresh closed fracture; good compliance; complete follow-up treatment.

Exclusion criteria: children with patent epiphysis, pathological fractures, vascular nerve injury, no surgical treatment, old fractures, low follow-up compliance, or incomplete follow-up.

Surgical procedure

Upon admission, the operation was attempted within 6 h of injury. Control group: The knee was flexed to an extreme position, with the calf perpendicular to the operating table. An approximately 4–5 cm longitudinal incision was made from the lower patellar pole to the tibial tubercle. After cutting through the skin and subcutaneous tissue, the patellar ligament was exposed and split from its midpoint. This incision exposed the anterior edge of the tibial plateau. A guide needle was subsequently inserted to confirm the location inside the lateral crest of the tibia. Reduction forceps or a "golden finger" assisted in reduction along the lateral edge of the anterior tibial plateau. If case reduction failed, a small incision was made at the fracture end for direct downward reduction. The medullary cavity was expanded, and an appropriately sized intramedullary nail was inserted, followed by near- and far-end locking, and placement of the tail cap. Confirmation of fracture reduction and internal fixation was done through fluoroscopy. The incision was flushed and stitched layer by layer (Fig. 1).

Test group: After disinfecting the sterile field, a sterile towel was placed under the calf. The knee was flexed at a 15–20° angle with the tibia facing straight forward. A 3 cm incision was made at the lateral edge of the patella,

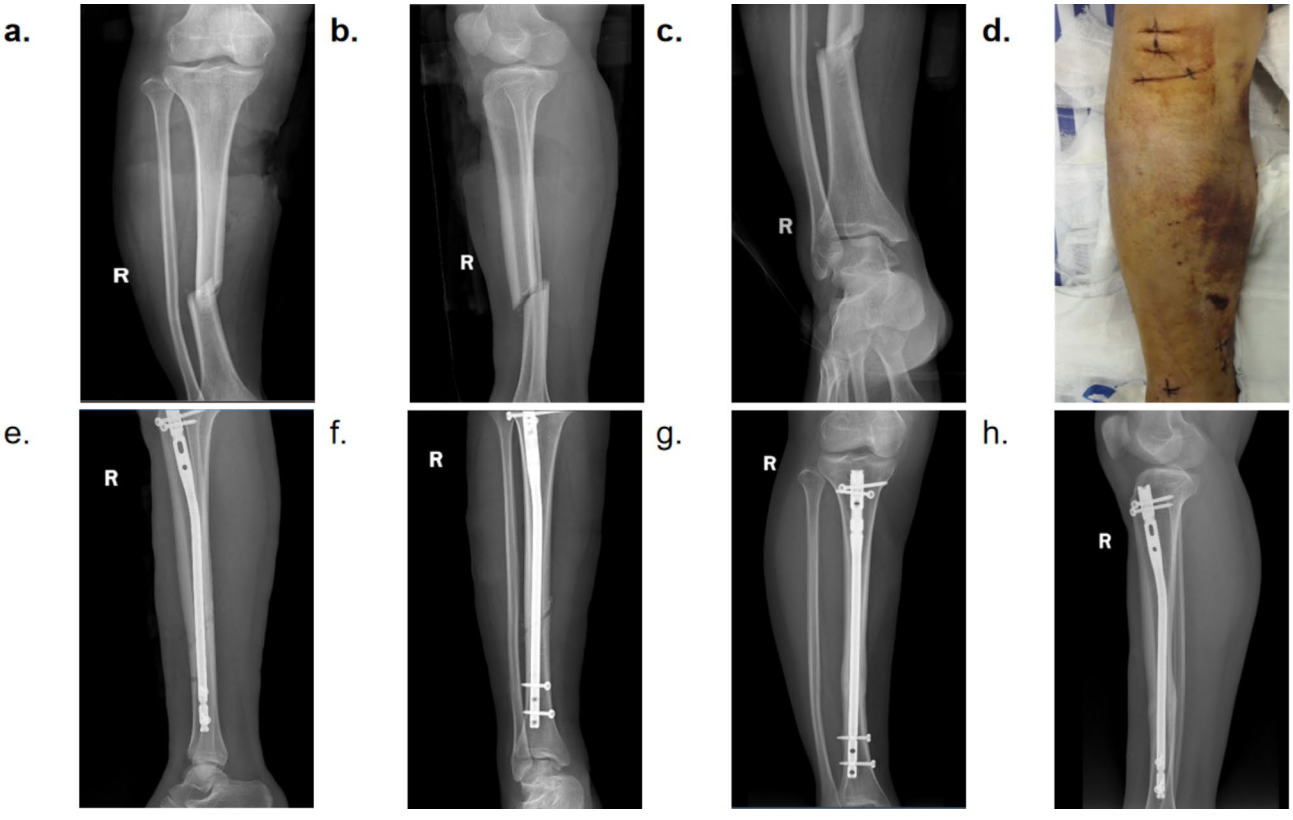

Fig. 1 A 20-year-old male patient with a right tibial shaft fracture (AO 42-A2.1 type) treated with internal fixation via the traditional split-patellar ligament approach. Images **a**-**c** depicting preoperative X-ray. Image **d** displaying the incision postoperatively; images **e** and **f** represent postoperative X-ray examinations; images **g** and **h** showing one-year postoperative reexaminations, indicative of a healed fracture

cutting through the skin and subcutaneous tissue. The parapatellar support band was opened 0.5 cm from the lateral edge of the patella, and the patellar ligament was pulled medially towards the highest point at the anterior edge of the tibial plateau. After confirming the satisfactory location for the needle injection point, a spherical guide needle was placed on the distal tibia. Closed reduction was performed using a point-type reduction clamp or a "gold finger." Blocking nails were placed if necessary. In case of unsuccessful closed reduction, a small incision was made at the fracture end to assist reduction. Once satisfactory reduction was achieved, the main nail was inserted using the same method, followed by near- and far-end locking. The wound was closed after irrigation (Fig. 2).

Postoperative management

Postoperatively, all patients received standard antibiotic prophylaxis to reduce the risk of infection. According to the infection control guidelines of our institution and the specific conditions of the patients, prophylactic antibiotics were administered for a duration of 24 h. It is important to note that the duration of antibiotic prophylaxis may vary depending on the infection control policies of different medical institutions and individual patient differences (such as age, comorbidities, etc.). Therefore, when generalizing the results of this study to other medical institutions, the potential impact of differences in antibiotic usage duration on postoperative infection rates and knee joint functional recovery should be considered.

Following surgery, patients were instructed to adhere to bed rest. Enoxaparin or low molecular weight heparin was prescribed to prevent deep venous thrombosis in the lower limbs. Once anesthesia wears off, patients are encouraged to initiate toe and ankle joint exercises, with knee joint exercises starting 48 h postoperatively. Upon subsiding of limb swelling, patients were encouraged to mobilize with the assistance of crutches. Weight-bearing was permitted on the affected limb upon the formation of continuous callus.

Follow-up status

All patients received full follow-up after surgery until the fracture had healed. The follow-up schedule is as follows: patients are seen monthly for the first month postoperatively, every two months from the second to the sixth month, and every three months from the seventh to the twelfth month. At each follow-up visit, the knee

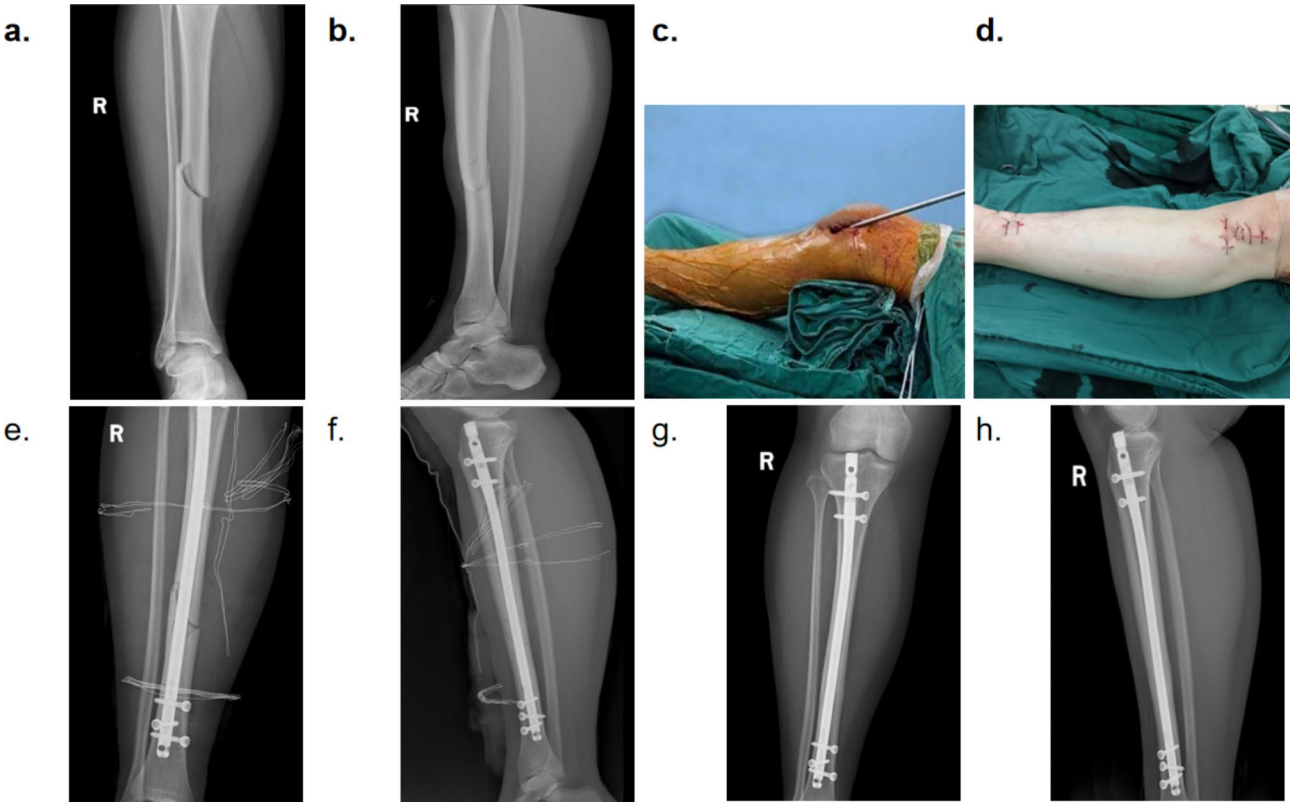

Fig. 2 A 38-year-old female patient with a right tibial shaft fracture (AO 42-A2.1 type) treated with internal fixation via a parapatellar approach. Images **a** and **b** exhibiting preoperative X-rays; image **c** highlighting the intraoperative surgical incision and intramedullary nail placement; image **d** showing the incision postoperatively; images **e** and **f** displaying postoperative follow-up X-rays; images **g** and **h** showing one-year follow-up X-rays, demonstrating fracture healing

joint function of the patients is assessed, and the treatment plan is adjusted according to the recovery situation. In addition, to promote the recovery of knee joint mobility, this study has adopted a standardized knee mobility rehabilitation protocol. Within 48 h after surgery, once the anesthesia has worn off, patients begin active exercises of the ankle and toes to promote blood circulation and prevent deep vein thrombosis. Subsequently, under the guidance of a professional rehabilitation therapist, knee flexion and extension exercises are gradually initiated. The exercise program includes passive flexion and extension, active-assisted flexion and extension, and active flexion and extension, conducted 2–3 times daily for 30 min each session. During the training process, the patient's pain and knee joint mobility are closely monitored, and the intensity and frequency of the training are adjusted according to the patient's tolerance to ensure the safety and effectiveness of the rehabilitation training.

Observational indicators

Various parameters were observed and recorded in both groups, including operation duration (from the start of surgery to completion of tail cap installation), number of fluoroscopy sessions, intraoperative blood loss, Visual Analog Scale (VAS) score for anterior knee pain at 24 h, 72 h, 1 week, and 1 month postoperatively, fracture healing time, and functional score of Lysholm knee at 12 months. The Lysholm Knee score primarily evaluates knee pain, instability, thigh muscle atrophy, swelling, lameness, ability to squat, climb stairs, and use of support. Scores above 95 are considered excellent, 94 to 85 are good, 84 to 65 are fair, and less than 65 are poor.

Statistical analysis

Statistical analysis was performed using IBM SPSS (Verion 22.0). Measurement data were expressed as mean ± standard deviation and count data were analyzed using the chi-square (x^2) test. The chi-square test was chosen for analyzing categorical data due to its suitability for comparing proportions between groups. This test is effective for evaluating differences in outcomes such as surgical approach success rates and complication incidences. No additional tests were used to validate these results, as the chi-square test provided sufficient statistical power for the categorical data in our study. No *p*-value adjustments were made for multiple comparisons in this study. The analyses were focused on primary outcomes, and the number of comparisons was limited to avoid the need for adjustments. This approach ensured the integrity of our findings without overcomplicating the statistical analysis.

Results

A total of 29 patients with tibial shaft fractures treated with intramedullary nails from March 2019 to January 2022 were divided into two groups based on the surgical approach. In the test group, 13 patients (eight women and five men) aged 31–70 years (averaging 57.92 ± 13.42 years) underwent tibial nailing via the lateral parapatellar approach. Causes of injury included six traffic accidents, five falls, and two other injuries. Fractures were classified into three cases of Arbeitsgemeinschaft für Osteosynthesefragen(AO) 42-A, four of type B, and six of type C.

In the control group, 16 patients (ten men and six women) aged 19–78 years (averaging 50.06 ± 14.01 years) underwent tibial nailing using the traditional subpatellar ligament split approach. Causes of injury included eight traffic accidents, seven falls, and one high fall. Fractures were classified into four cases of AO 42-A, six of type B, and six of type C. In terms of previous knee injuries, two patients in the test group and three patients in the control group had a history of such injuries. Regarding comorbidities, the test group included two patients with diabetes, one with hypertension, and one with coronary heart disease. In the control group, there were three patients with diabetes, two with hypertension, and one with coronary heart disease. The two groups had no considerable difference in general data (Table 1).

Both groups completed the surgery. The mean operation duration was 95.00 ± 25.02 min in the test group and 93.63 ± 22.16 min in the control group, with no substantial difference between the two groups ($P = 0.88$). The average blood loss was 173.08 ± 105.94mL in the test group and 151.88 ± 59.13mL in the control group, showing no significant difference between the two groups ($P = 0.50$). Bone healing was achieved in both groups. The fracture healing time was 16.38 ± 2.87 weeks in the test group and 17.25 ± 2.08 weeks in the control group, with no significant difference ($P = 0.36$) (Table 2).

The intraoperative fluoroscopy count was 4.85 ± 0.80 in the test group and 5.19 ± 0.91 in the control group. There was no considerable difference between the two groups ($P = 0.3$). Regarding the VAS score, the test group showed superior outcomes compared to the control group at 24 h, 72 h, and 1 week postoperative ($P < 0.05$). There was a significant difference in the VAS score between the two groups at 1 month postoperatively ($P = 0.03$) (Table 3). The lower VAS scores in the parapatellar group during these critical periods have important clinical implications. In the first 24 h, immediate pain relief is crucial for patient comfort and satisfaction. Lower pain levels can reduce the need for high-dose analgesics, mitigating risks associated with opioid use. At 1 week, reduced pain facilitates early mobilization and adherence to rehabilitation protocols, preventing complications like joint stiffness

Table 1 Comparison of general data between the two groups

Study groups	Example number	Sex		Age	Traffic accidents	Fall injuries	High-fall injuries	AO Type			Previous Knee Injuries	Comorbidities		
		Man	Woman					A	B	C		Diabetes	Hypertension	Coronary Heart Disease
Test Group	13	8	5	57.91 ± 13.42	8	7	1	3	4	6	2	1	1	2
Control Group	16	10	6	50.06 ± 14.01	6	5	2	4	6	6	3	2	1	3
t/χ^2		1.69		1.53	0.41			0.38			0.23	0.74		
P		0.19		0.14	0.68			0.75			0.88	0.78		

This table presents the demographic and injury characteristics of patients in the test and control groups. Abbreviations used include AO (Arbeitsgemeinschaft für Osteosynthesefragen), which refers to the classification system for fractures

Table 2 Comparison of intraoperative duration, bleeding volume, and fracture healing time between the two groups

Study groups	Example number	Intraoperative duration (min)	Intraoperative blood loss volume (mL)	Fracture healing time (weeks)
Test Group	13	95.00 ± 25.02	173.08 ± 105.94	16.38 ± 2.87
Control Group	16	93.63 ± 22.16	151.88 ± 59.13	17.25 ± 2.08
t		0.16	0.68	0.94
P		0.88	0.50	0.36

This table compares the surgical outcomes of the test and control groups. The intraoperative duration refers to the time from the start of surgery to the completion of tail cap installation. Intraoperative blood loss is measured in milliliters, and fracture healing time is the duration in weeks from surgery to the point of healed fracture

and muscle atrophy. These factors contribute to faster recovery and improved functional outcomes.

Furthermore, decreased pain in the early postoperative period enhances patient satisfaction and quality of life. Patients with lower pain levels are more likely to view their surgical outcome positively, which can improve their psychological well-being and motivation for recovery.

At the 12-month follow-up, Knee Lysholm scores were assessed in both groups. There were no significant differences in knee support, locking, or swelling ($P > 0.05$). However, the test group exhibited substantially better outcomes regarding lameness, instability, stair climbing, squatting, and pain ($P < 0.05$). Specifically, nine cases were rated as excellent and four as good in the test group, whereas in the control group, five cases were rated as excellent, with three rated as good. The differences between the two groups were evident ($P = 0.01$) (Table 4). The differences in Lysholm scores observed in our study are promising and suggest that the parapatellar approach may offer significant advantages in improving knee function following tibial intramedullary nailing. A detailed analysis of the specific items within the Lysholm score reveals that certain aspects of knee function were particularly affected by the surgical approach used. For lameness, the parapatellar group showed a significant improvement compared to the subpatellar group. This can be attributed to the reduced soft-tissue damage and joint disruption associated with the parapatellar approach, which avoids splitting the patellar ligament and minimizes patellofemoral joint pressure, contributing to better alignment and stability of the knee joint and resulting in less noticeable limping during ambulation. Regarding instability, patients in the parapatellar group reported less instability, likely due to the preservation of the patellar ligament's integrity, which plays a crucial role in maintaining knee stability. In contrast, the subpatellar approach, which involves ligament splitting, can lead to scarring and fibrosis, potentially compromising

Table 3 Comparison of intraoperative fluoroscopy count and visual Analog Scale (VAS) scores at different timepoints in the two groups

Study group	Example number	Intraoperative fluoroscopy count	VAS grade			
			24 h postoperative	72 h postoperative	One week postoperative	One month postoperative
Test Group	13	4.85 ± 0.80	6.62 ± 0.87	3.15 ± 0.38	0.77 ± 0.6	1.38 ± 0.49
Control Group	16	5.19 ± 0.91	7.44 ± 1.03	3.56 ± 0.51	2.31 ± 0.48	1.55 ± 0.51
t/χ^2		1.06	2.29	2.40	2.72	2.22
P		0.30	0.03	0.02	0.01	0.03

This table shows the number of fluoroscopy sessions used during surgery and the VAS scores for knee pain at various postoperative timepoints. The VAS is a tool used to measure pain intensity, with higher scores indicating greater pain

the ligament's ability to provide adequate support. The parapatellar group also exhibited significant improvements in their ability to climb stairs and squat, activities that require strong quadriceps function and intact joint mechanics. By minimizing damage to surrounding soft tissues and joint structures, the parapatellar approach likely facilitates better recovery of quadriceps strength and joint mobility, enabling patients to perform these functional tasks more effectively. Additionally, lower pain levels were reported in the parapatellar group, particularly in relation to daily activities and movement, aligning with the overall findings of reduced postoperative pain using this approach. Less pain enhances patients' ability to engage in physical activities and improves their overall quality of life.

Discussion

Our study's findings on knee pain following tibial nailing using the parapatellar approach can be contextualized by comparing them with existing literature on different surgical techniques. The subpatellar approach, which often results in high incidences of anterior knee pain, aligns with our control group findings, where chronic pain was reported in a significant percentage of patients. This is likely due to damage to the patellar ligament and infrapatellar fat pad. In contrast, the suprapatellar approach, while preserving the patellar ligament, may increase patellofemoral joint pressure, leading to comparable pain levels. Our results support the benefits of the minimally invasive parapatellar approach, which showed significant improvements in VAS and Lysholm scores, consistent with reduced soft-tissue damage and joint disruption.

Comparison with other studies

The findings of our study on knee pain following tibial nailing using the parapatellar approach can be contextualized by comparing them with existing literature on different surgical techniques. The subpatellar approach, which often results in high incidences of anterior knee pain, was similar to our control group findings, with Nork et al. reporting chronic pain in 40% of patients [31]. This aligns with our observation of higher VAS scores and lower Lysholm scores in the subpatellar group, likely due to damage to the patellar ligament and infrapatellar fat pad .

In contrast, the suprapatellar approach preserves the patellar ligament but may increase patellofemoral joint pressure, as noted in a systematic review by Bleeker et al., which found no significant difference in pain levels compared to the subpatellar approach [32]. Recent advancements in minimally invasive techniques, such as the lateral parapatellar approach used in our study, have shown promising results. Patel et al. validated this approach as extra-articular, reporting reduced postoperative pain and improved knee function [33]. Our findings support these results, demonstrating significant improvements in VAS scores and Lysholm scores, particularly in pain, lameness, and instability. These improvements are consistent with the benefits of minimizing soft-tissue damage and joint disruption.

Limitations and future research

Our study has several limitations, including a small sample size and a follow-up period limited to 12 months. These factors may affect the generalizability of our results and our ability to assess long-term outcomes. Future research should focus on larger sample sizes and extended follow-up periods to evaluate the durability of pain reduction and functional improvements beyond 12 months. Additionally, studies could explore the impact of patient-specific factors, such as age and comorbidities, on postoperative outcomes. Large-scale, multicenter studies would help validate the approach's efficacy and safety, providing valuable insights into its potential to mitigate chronic pain and improve long-term functional outcomes. Such research would also help identify any specific patient characteristics or surgical factors that may influence the approach's effectiveness, guiding the development of more personalized surgical strategies.

Alignment with ERAS protocols

Minimally invasive surgical techniques, such as the parapatellar approach, align well with enhanced recovery after surgery (ERAS) protocols. ERAS aims to optimize patient outcomes by reducing surgical stress and promoting early recovery. The parapatellar approach minimizes

Table 4 Comparison of knee lysholm scores at 12 months between the two groups

	Example number	Lameness	Squatting	Hanging lock	Instability	Swelling	Stair climbing	Crouching	Pain	Good rate			
										sample	good people	center	difference
Test Group	13	4.85 ± 0.56	4.77 ± 0.83	14.62 ± 1.39	24.62 ± 1.39	9.38 ± 1.50	9.38 ± 1.50	4.69 ± 0.75	23.85 ± 3.00	9	4	0	0
Control Group	16	4.0 ± 1.03	4.81 ± 0.75	13.75 ± 2.24	22.19 ± 3.15	8.25 ± 2.05	7.63 ± 2.22	3.81 ± 1.28	20.94 ± 3.75	5	3	8	0
χ^2		2.65	0.15	1.22	2.58	1.66	2.44	2.19	2.27	2.64			
P		0.01	0.88	0.24	0.02	0.11	0.02	0.04	0.03	0.01			

This table presents the Lysholm knee scores at 12 months postoperatively. The Lysholm score evaluates knee function based on several criteria, including pain, instability, and ability to perform daily activities. Higher scores indicate better knee function

soft-tissue damage and joint disruption, which is consistent with ERAS principles. Literature on similar minimally invasive techniques has shown that they can lead to reduced postoperative pain, faster mobilization, and improved patient satisfaction [34, 35]. By adopting such techniques, surgeons can enhance patient outcomes and align their practices with the broader goals of ERAS. The combination of minimally invasive surgery with ERAS protocols has been shown to improve clinical outcomes significantly [36]. By minimizing surgical stress and promoting early mobilization, the parapatellar approach can contribute to faster recovery and reduced complications, which are key objectives of ERAS protocols [37].

Conclusion

Our study demonstrates that using the parapatellar approach for tibial intramedullary nailing effectively minimizes postoperative knee pain and improves functional outcomes. By avoiding the need to split the patellar ligament and enter the joint cavity, this approach reduces the impact on the knee joint. The results show significant improvements in pain levels and knee function, as evidenced by lower VAS scores and better Lysholm scores in the parapatellar group. However, the small sample size limits the generalizability of our findings. Further research with larger cohorts and longer follow-up periods is necessary to fully understand the long-term benefits and mechanisms of this surgical approach in reducing knee pain and enhancing recovery after tibial intramedullary nailing.

Acknowledgements

We thank the editor and series editor for their constructive criticisms of an earlier version of this manuscript. We also would like to thank Bullet Edits Limited for the guistic editing and proofreading of the manuscript.

Author contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Shaoyu Han and Zhixiang Chen. The first draft of the manuscript was written by Bingjun Cui and Lang Wu. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Funding

This work was supported by the Huaiyin District Health Science and Technology Development Project(HYWJ2024004, HYWJ2024013) and the Jiangsu Vocational College of Nursing-Integrated Scientific and Educational Clinical Research Project (KRHW2406, KRHW2407).

Data availability

Data is provided within the manuscript or supplementary information files.

Declarations

Ethics approval and consent to participate

This study has been approved by The Ethics Committee of Huai'an Hospital affiliated to Yangzhou University, approved this study with approval number KY-P-2022-015-01, in written form. All participants of this study were carefully informed about the relevant content of the research. Written consent was obtained from all participants.

Consent for publication
We have confirmed that all participants provided written consent for the publication of their anonymized data, including age.

Competing interests
The authors declare no competing interests.

Received: 28 July 2024 / Accepted: 13 January 2025
Published online: 29 January 2025

References

1. Coelho Fernandes AR, Sagoo KS, Oluku J, Cheema KS. Tibial malrotation following intramedullary nailing: a literature review. Cureus. 2021;13(11):e19683. https://doi.org/10.7759/cureus.19683. Published 2021 Nov 17.
2. Xia L, Zhou J, Zhang Y, Mei G, Jin D. A meta-analysis of reamed versus unreamed intramedullary nailing for the treatment of closed tibial fractures. Orthopedics. 2014;37(4):e332–8. https://doi.org/10.3928/01477447-20140401-52
3. Zelle BA, Boni G. Safe surgical technique: intramedullary nail fixation of tibial shaft fractures. Patient Saf Surg. 2015;9:40. https://doi.org/10.1186/s13037-015-0086-1
4. Akhoundzadeh D, Bloemers FW, Verhofstad MHJ, Schoonmade LJ, Geeraedts LMG Jr. Which surgical technique may yield the best results in large, infected, segmental non-unions of the tibial shaft? A scoping review. Eur J Trauma Emerg Surg. 2024;50(4):1537–45. https://doi.org/10.1007/s00068-024-02478-y
5. Jones M, Parry M, Whitehouse M, Mitchell S. Radiologic outcome and patient-reported function after intramedullary nailing: a comparison of the retropatellar and infrapatellar approach. J Orthop Trauma. 2014;28(5):256–62. https://doi.org/10.1097/BOT.0000000000000070
6. Eastman JG, Tseng SS, Lee MA, Yoo BJ. The retropatellar portal as an alternative site for tibial nail insertion: a cadaveric study. J Orthop Trauma. 2010;24(11):659–64. https://doi.org/10.1097/BOT.0b013e3181f6bec7
7. Leary J, Werger M, Sagebien C. A novel technique for percutaneous removal of a suprapatellar intramedullary nail. Am J Orthop (Belle Mead NJ). 2013;42(3):136–40. PMID: 23527331.
8. Bhattacharyya TMD, Seng KMD, Nassif, Nader AMD, Freedman, Ilan MBBS. August. Knee pain after tibial nailing: the role of nail prominence. Clinical Orthopaedics and Related Research. 2006;449:303–307. | https://doi.org/10.1097/01.blo.0000223976.91089.08
9. Patel AH, Wilder JH, Lee OC, et al. A review of proximal tibia entry points for intramedullary nailing and validation of the lateral parapatellar approach as extra-articular. Orthop Rev (Pavia). 2022;14(1):31909. https://doi.org/10.52965/001c.31909. Published 2022 Jan 30.
10. Ozcan C, Turkmen I, Sokucu S. Comparison of three different approaches for anterior knee pain after tibia intramedullary nailing. Eur J Trauma Emerg Surg. 2020;46(1):99–105. https://doi.org/10.1007/s00068-018-0988-6
11. Mu YY, Liu B, Chen B, et al. Evaluation of association studies and an updated meta-analysis of VDR polymorphisms in osteoporotic fracture risk. Front Genet. 2022;12:791368. https://doi.org/10.3389/fgene.2021.791368. Publishe d 2022 Jan 7.
12. Zhang R, Huang Q, Su G et al. Association between multiple vitamins and bone mineral density: a cross-sectional and population-based study in the NHANES from 2005 to 2006. BMC Musculoskelet Disord. 2023;24(1):113. Published 2023 Feb 10. https://doi.org/10.1186/s12891-023-06202-6
13. Zhang J, Bradshaw F, Hussain I, Karamatzanis I, Duchniewicz M, Krkovic M. The epidemiology of lower limb fractures: a major United Kingdom (UK) trauma centre study. Cureus. 2024;16(3):e56581. https://doi.org/10.7759/cureus.56581. Published 2024 Mar 20.
14. Petersen KK. Chronic postoperative pain after total knee arthroplasty: the potential contributions of synovitis, pain sensitization and pain catastrophizing-an explorative study. Eur J Pain. 2022;26(9):1979–89. Epub 2022 Aug 19.
15. Liang W, Zhou C, Bai J, et al. Current advancements in therapeutic approaches in orthopedic surgery: a review of recent trends. Front Bioeng Biotechnol. 2024;12:1328997. https://doi.org/10.3389/fbioe.2024.1328997. Published 2024 Feb 9.
16. Migliorini F, Feierabend M, Hofmann UK. Fostering excellence in knee arthroplasty: developing optimal patient care pathways and inspiring knowledge transfer of advanced surgical techniques. J Healthc Leadersh. 2023;15:327–38. https://doi.org/10.2147/JHL.S383916. Published 2023 Nov 21.
17. Toivanen JA, Honkonen SE, Koivisto AM, Järvinen MJ. Treatment of low-energy tibial shaft fractures: plaster cast compared with intramedullary nailing. Int Orthop. 2001;25(2):110–3. https://doi.org/10.1007/s002640000083
18. Althausen PL, Neiman R, Finkemeier CG, Olson SA. Incision placement for intramedullary tibial nailing: an anatomic study. J Orthop Trauma. 2002 Nov-Dec;16(10):687–90. https://doi.org/10.1097/00005131-200211000-00001
19. Morandi M, Rose MK, Mangano S. Update in tibia intramedullary nailing: percutaneous suprapatellar access route with the knee in semiextended position for intramedullary stabilization of tibia fractures[J]. Techniques in Orthopaedics. 2014;29(2):56–61. https://doi.org/10.1097/BTO.0000000000000075
20. Beltran MJ, Collinge CA, Patzkowski JC, Masini BD, Blease RE, Hsu JR, Skeletal Trauma Research Consortium (STReC). Intra-articular risks of suprapatellar nailing. Am J Orthop (Belle Mead NJ). 2012;41(12):546–50. PMID: 23550286.
21. Jakma T, Reynders-Frederix P, Rajmohan R. Insertion of intramedullary nails from the suprapatellar pouch for proximal tibial shaft fractures. A technical note. Acta Orthop Belg. 2011;77(6):834–7. PMID: 22308632.
22. Al-Azzawi M, Davenport D, Shah Z, Khakha R, Afsharpad A. Suprapatellar versus infrapatellar nailing for tibial shaft fractures: a comparison of surgical and clinical outcomes between two approaches. J Clin Orthop Trauma. 2021;17:1–4. https://doi.org/10.1016/j.jcot.2021.01.009. Published 2021 Jan 29.
23. Casola L, Iglesias M, Matías-Joannas G, Eslava S, Martinez MJ, Gaillard JM, et al. Suprapatellar nail - the gold standard in the treatment of tibia fractures. J Foot Ankle. 2023;17(3):148–55.
24. Toivanen JA, Väistö O, Kannus P, Latvala K, Honkonen SE, Järvinen MJ. Anterior knee pain after intramedullary nailing of fractures of the tibial shaft. A prospective, randomized study comparing two different nail-insertion techniques. J Bone Joint Surg Am. 2002;84(4):580–5. https://doi.org/10.2106/00004623-200204000-00011
25. Orfaly R, Keating JE, O'Brien PJ. Knee pain after tibial nailing: does the entry point matter? J Bone Joint Surg Br. 1995;77(6):976-7. PMID: 7593119.
26. Obremskey W, Agel J, Archer K, To P, Tornetta P 3, SPRINT Investigators. Character, incidence, and predictors of knee pain and activity after infrapatellar intramedullary nailing of an isolated tibia fracture. J Orthop Trauma. 2016;30(3):135–41. https://doi.org/10.1097/BOT.0000000000000475
27. Comadoll SM, Jinnah AH, Miller AN, Aneja AMD. December. Transpatellar approach: intramedullary nailing of the tibia through an open patella fracture. Techniques in Orthopaedics. 2021;36(4):405–408. | https://doi.org/10.1097/BTO.0000000000000461
28. Hampp EL, Sodhi N, Scholl L, Deren ME, Yenna Z, Westrich G, Mont MA. Less iatrogenic soft-tissue damage utilizing robotic-assisted total knee arthroplasty when compared with a manual approach: a blinded assessment. Bone Joint Res. 2019;8(10):495–501. https://doi.org/10.1302/2046-3758.810.BJR-2019-0129
29. Bohan ZHANG, Yinqiao DU, Jingyang SUN, Junmin SHEN, Tiejian LI, Yonggang ZHOU. Prevention and treatment of iatrogenic medial collateral ligament injuries in total knee arthroplasty. Chin J Reparative Reconstr Surg. 2021;35(1):14–9. https://doi.org/10.7507/1002-1892.202004126
30. Thwaites S, Abrahams J, Thewlis D, Rickman M. The absence of reporting standards and a lack of objective, performance-based outcomes following intramedullary nailing of tibial shaft fractures: findings from a scoping review into 179 articles [published correction appears in Eur J Trauma Emerg Surg. 2024;50(2):619. doi: 10.1007/s00068-023-02380-z]. Eur J Trauma Emerg Surg. 2024;50(1):59–70. https://doi.org/10.1007/s00068-023-02338-1
31. Nork SE, Schwartz AK, Agel J, Holt SK, Schrick JL, Winquist RA. Intramedullary nailing of distal metaphyseal tibial fractures. J Bone Joint Surg Am. 2005;87(6):1213–21. https://doi.org/10.2106/JBJS.C.01135
32. Bleeker NJ, Reininga IHF, van de Wall BJM, et al. Difference in pain, complication rates, and clinical outcomes after suprapatellar versus infrapatellar nailing for tibia fractures? A systematic review of 1447 patients. J Orthop Trauma. 2021;35(8):391–400. https://doi.org/10.1097/BOT.0000000000002043
33. Lu Y, Wang G, Hu B et al. Comparison of suprapatellar versus infrapatellar approaches of intramedullary nailing for distal tibia fractures. J Orthop Surg Res. 2020;15(1):422. Published 2020 Sep 17. https://doi.org/10.1186/s13018-020-01960-8
34. Chen CC. Zhonghua Wei Chang Wai Ke Za Zhi. 2022;25(7):632–5. https://doi.org/10.3760/cma.j.cn441530-20220323-00113
35. Kehlet H, Wilmore DW. Multimodal strategies to improve surgical outcome. Am J Surg. 2002;183(6):630–41. https://doi.org/10.1016/s0002-9610(02)00866-8

36. Pache B, Hübner M, Jurt J, Demartines N, Grass F. Minimally invasive surgery and enhanced recovery after surgery: the ideal combination? J Surg Oncol. 2017;116(5):613–6. https://doi.org/10.1002/jso.24787
37. Kubitz JC, Schubert AM, Schulte-Uentrop L. Enhanced recovery after surgery (ERAS®) in Der Kardioanästhesie [Enhanced recovery after surgery (ERAS®) in cardiac anesthesia]. Anaesthesiologie. 2022;71(9):663–73. https://doi.org/10.1007/s00101-022-01190-z

Publisher's note