Trauma Case Reports 51 (2024) 101018

Contents lists available at ScienceDirect

Trauma Case Reports

journal homepage: www.elsevier.com/locate/tcr

Case Report

Use of metatarsal hook plates in the treatment of multifragmentary patellar fractures - A case series☆

Edgar Alejandro Barros [a], Carlos Ballesteros [a], Carlos Eduardo Noboa [a], Gonzalo Arteaga [a], Carlos Peñaherrera [b], Francisco Endara [b], Andrés Bravo [c], Alejandro Xavier Barros Castro [b,*]

[a] *Orthopedics and Traumatology Service, Hospital Vozandes Quito and Hospital Metropolitano, Quito - Ecuador*
[b] *Postgraduate Course in Orthopedics and Traumatology at the International University of Ecuador, Quito - Ecuador*
[c] *Posgraduate Course in Orthopedics and Traumatology at Universidad de las Americas- Quito- Ecuador*

ARTICLE INFO

Keywords:
Fracture osteosynthesis
Patella fracture
Bone plates
Orthopedic fixation devices
Fracture fixation

ABSTRACT

The surgical management of patellar fractures typically yielded satisfactory results; however, in situations involving multifragmented patellar fractures or those affecting the inferior pole, it became imperative to employ alternative osteosynthesis techniques that enhanced stability, enabled early rehabilitation initiation, prevented implant failure, and avoided reduction loss before fracture consolidation. In this context, an unconventional osteosynthesis alternative was presented, utilizing an anatomically designed hook plate originally intended for the fifth metatarsal. This technique was successfully applied in three patients with multifragmentary patellar fractures, allowing stable fixation of small or marginal fragments through the plate's hooks without compromising vascularity. Fracture consolidation was achieved without reduction loss, and owing to its low profile, patient discomfort and irritation were minimized compared to traditional tension band or wiring techniques. This approach suggested the potential to forego early plate removal, thereby contributing to a more effective management of patellar fractures.
Level of evidence: IV.

Introduction

Patellar fractures were a low-frequency pathology in the population, representing approximately 1% of all fractures recorded annually. However, only around one-third of these cases required surgical intervention [1,2]. The surgical approach targeted fractures with more than 2 mm of articular displacement or 3 mm of separation between fragments. This approach varied from patellectomy in irreconstructible multifragmentary fractures to closed reduction with percutaneous fixation in transverse or longitudinal fractures, as well as open reduction and internal fixation. Despite its implications, patellectomy lost indication due to a decrease in the effectiveness of the extensor mechanism by up to 30%. Although patellar fractures had a low incidence, inadequate treatment could result in disabling consequences, incurring high costs for both the patient and the healthcare system. These consequences included the possibility of developing stiffness, loss of range of motion, or even favoring the development of patellofemoral arthritis [1,3–5].

☆ The published images and photographs were authorized by the patients through informed consent.

* Corresponding author at: Hospital Vozandes Quito, Villalengua Oe2-37 y Veracruz, Quito, Ecuador.
E-mail address: alejandroxbc27@gmail.com (A.X. Barros Castro).

https://doi.org/10.1016/j.tcr.2024.101018
Accepted 6 April 2024
Available online 8 April 2024

Given the limitation of plain radiographs to provide comprehensive information about fracture characteristics, especially in cases of multifragmentary fractures or those involving the inferior pole, preoperative computed tomography (CT) was recommended [6]. CT had a greater capacity to delineate or evaluate fracture patterns, determine the number of fragments, and assist in choosing the most appropriate osteosynthesis. The morphology of fractures of the inferior pole of the patella, for example, was identified in 88% through CT, while plain radiographs only managed to identify 44% of cases [7].

These fractures could be classified based on the causal mechanism, either low energy or high energy, with the latter linked to multifragmentary fractures [8–10]. The most common fractures were transverse with two fragments, although a small percentage presented multifragmentary fractures, which were more challenging to treat [11].

The classification of patellar fractures was based on various parameters, considering the degree of displacement (undisplaced versus displaced with a gap greater than 2 mm), fracture pattern (transverse, vertical, marginal, osteochondral, or comminuted), and the specific location of the fracture (central, proximal, or in the distal third). Through the AO/OTA classification, categorization was done into extraarticular, partially articular, and completely articular fractures, with their respective sub-classifications. However, it was important to note that this classification method did not address the morphology of fractures of the inferior pole of the patella, which was crucial for determining the most appropriate treatment [12].

In terms of surgical treatment, various osteosynthesis options had been described, such as conventional [13–15], or modified tension band wiring, the use of circular wire [16], high-strength sutures [17], cannulated screws with tension band for simple fractures [18,19], and plates with various designs for multifragmentary fractures (basket type [5,20], locking plate [10,21,22], hook plate [23,24], hook plate plus wiring [22], mesh plate [25]). These methods should allow fracture consolidation within a period of 8 to 12 weeks, during which the patella underwent approximately 100,000 cycles of flexion and extension, imposing a high demand on any treatment approach [11,26].

The treatment objectives were to achieve anatomical reduction, stable fixation that restored both the articular surface and the extensor mechanism, and enabled early rehabilitation [2,10,11,18,19,23,27]. Failure to achieve these objectives could result in the early onset of femoropatellar osteoarthritis, manifested by decreased mobility and, ultimately, stiffness and persistent knee pain1. Treatment selection was individualized and depended on various factors, including fracture pattern, extent of soft tissue damage, number and size of fragments, bone quality, congruence of the articular surface, stability of the extensor mechanism, and patient cooperation [3,11].

Why the anatomical hook plate for the fifth metatarsal?

Despite the availability of basket, mesh, or specific locked plates for the patella, this study was conducted to evaluate the functional and radiological results derived from the use of an anatomical hook plate designed for the fifth metatarsal. The hypothesis was based on the idea that this plate offered effective reduction in multifragmentary patellar fractures, thanks to its molding capability that allowed adaptation to the anterior surface of the patella, considering the variability in the pattern of such fractures. Additionally, its low profile minimized subcutaneous irritation, especially in such a mobile joint as the knee. An additional advantage was observed that the plate's hooks enabled the fixation of small fragments. The locked nature of the plate provided a significant advantage, especially in osteoporotic bones.

Surgical technique

The patient was placed in the supine position on an orthopedic table, with support under the ipsilateral hip and the application of a tourniquet. A longitudinal anterior approach was performed, extending from the upper edge of the patella to the anterior tibial tubercle, preserving a single flap to ensure cutaneous circulation and conserving the periosteum of the fragments, crucial in the inferior region of the patella. This incision had to be carefully planned to preserve the peripatellar ring, which constituted the source of the entire blood supply to the patella, especially the inferior patellar network. Identification and debridement of the fragments were carried out with irrigation of saline solution at body temperature, ensuring coronal plane deimpaction to achieve anatomical reduction of the articular surface.

Since the retinaculum and joint capsule were commonly affected, the quality of reduction and manipulation of fragments was easily observable. Reduction forceps were used to provisionally fix the fragments, stabilizing them with 0.7 mm to 1 mm Kirschner wires. Subsequently, definitive fixation was performed using mini-screws, micro-fragment screws, or headless cannulated compression screws, depending on the size of the fragments. Finally, a radiographic control with an image intensifier was performed to ensure anatomical reduction, and under direct visualization, reconstruction of the articular surface was confirmed, provided it was compromised.

Once anatomical reconstruction of the patella was achieved, the optimal site for placing the pre-molded left and/or right hook plate for the fifth metatarsal was assessed. The hooks could be proximal, distal, or oblique, depending on the fracture pattern. The oval hole in the plate was utilized to provide compression to the main fracture focus. The plate was bent at the end opposite to the hooks to adapt to the shape of the patella, and a long screw parallel to the articular surface was inserted. It had to be ensured that the osteosynthesis material respected the articular surface, avoiding damage to articular cartilage. The stability of the osteosynthesis was verified through passive intraoperative flexion-extension movements, followed by anteroposterior, lateral, and axial radiographs. Finally, layered closure was performed with the knee semi-flexed at approximately 30°.

Materials and methods

In this article, a secondary research investigation was conducted by consulting various medical databases such as PubMed, Cochrane, Science Direct, and ISCIII. Mesh terms were employed to obtain sources of information.

The PRISMA method was followed for the selection of different articles from which relevant information was extracted. The classification of these articles was done according to the level of evidence, following the Oxford criteria. The literature review predominantly sought to include systematic reviews and clinical trials.

This study constituted a retrospective cohort investigation conducted from September 2021 to December 2023. In total, four fractures in three patients were addressed through open reduction and osteosynthesis procedures using the anatomically blocked hook plate designed for the fifth metatarsal (Baby Gorilla 5th Metatarsal Plating System - Paragon 28). Follow-up was carried out for a maximum duration of 3 years and 3 months, and a minimum of 6 months.

The inclusion criteria were as follows: (1) Patients with multifragmentary fractures with AO classification 34 - C2 and C3, (2) Patients treated with anatomical hook plate for the fifth metatarsal (Baby Gorilla 5th Metatarsal Plating System - Paragon 28), (3) Patients with a minimum follow-up of 6 months with complete clinical and radiographic examinations. Exclusion criteria were (1) pathological or non-traumatic fractures, (2) patients with previous knee osteoarthritis, (3) simple linear fractures.

All patients underwent anteroposterior and lateral knee radiographs. The patients included two females and one male. The patient in case 1 was a 15-year-old female with a history of an 8-m fall, with bilateral multifragmentary patellar fractures (Fig. 1), who also had bilateral open G II femoral fractures and bilateral Lisfranc fractures. The second case involved an 83-year-old man patient (Fig. 2) with a history of a with a clinical history of type 2 diabetes mellitus, hypertension treated with antithrombotic medication (Warfarin), and relevant orthopedic history, including calcification at the proximal end of the patellar tendon. The third case involved a 53-year-old female patient (Fig. 3) with no significant clinical history.

The patients of case one and tree underwent surgery within the first 6 h of trauma, while the second patient was operated on the 3rd day due to the mentioned medical history. We utilized the AO classification and a classification based on morphological characteristics according to the computed tomography (CT) and the follow-up times for each case are described in Table 1.

Follow-up assessments for all cases were conducted within the initial 15 days post-surgery, followed by evaluations at one, three, six, and twelve months thereafter. The radiographic evaluation for Case 1 at the 30-month milestone is depicted in Fig. 4, while the radiographic follow-up for Case 2 is presented at two weeks and twelve months in Fig. 5.

A standardized physiotherapy protocol was implemented, commencing on the 2nd postoperative day, involving passive and active knee mobilization according to tolerance during the first two postoperative weeks, with an emphasis on achieving maximum extension during rest periods. Partial weight-bearing (toe-touch) on the injured limb was permitted with the assistance of crutches.

From the 3rd to the 6th postoperative week, active flexion up to 90° was sought, and after the 6th week, the first radiographic control was performed. Following this control, full range of motion was authorized, achieved at 3 months postoperatively in all patients.

Among the postoperative complications, one case reported anterior knee pain. A year after surgery, the patient experienced clinical symptoms while ascending and descending stairs, leading to implant removal. Additionally, arthroscopy was performed to address osteomalacia, and subsequently, symptoms were completely alleviated (Fig. 6).

The modified Cincinnati Knee Rating System (CKRS) was employed for postoperative evaluation. The CKRS was a functional assessment instrument and questionnaire designed to examine knee functionality. Originally developed to analyze treatment outcomes for chronic anterior cruciate ligament (ACL) deficiency, the CKRS had proven useful for patients undergoing various surgical

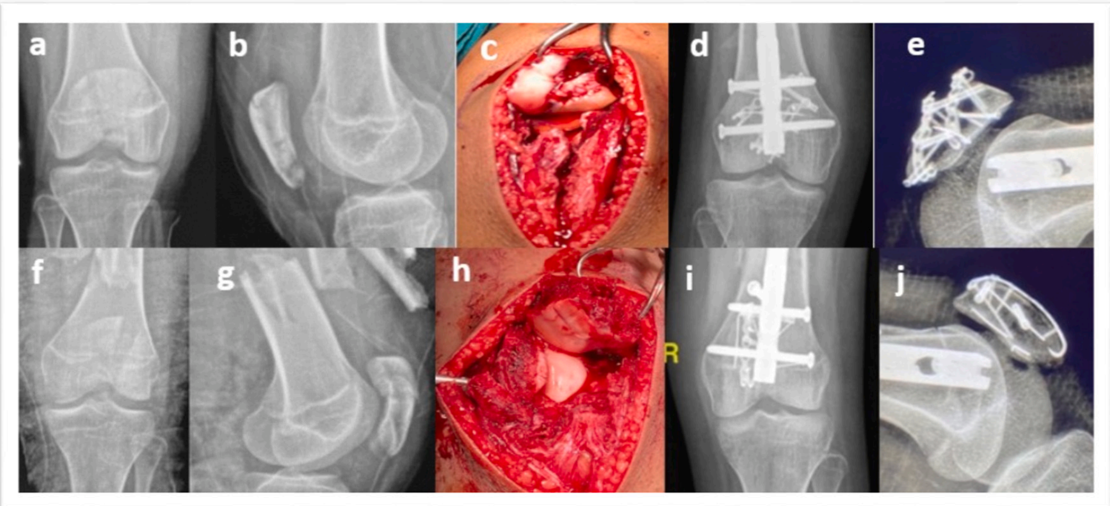

Fig. 1. Case 1: a and b); preoperative anteroposterior and lateral radiographs of the right knee, c); intraoperative photograph of the right multifragmentary patellar fracture, d and e); immediate postoperative anteroposterior and lateral radiographs of the right knee, f and g); preoperative anteroposterior and lateral radiographs of the left knee, h); intraoperative photograph of the left multifragmentary patellar fracture, i and j); immediate postoperative anteroposterior and lateral radiographs of the left knee.

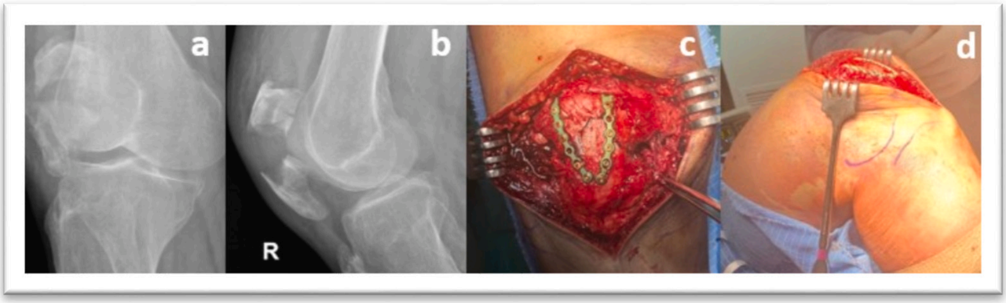

Fig. 2. Case 2: a and b) Preoperative anteroposterior and lateral X-ray of the left knee, c) intraoperative photos after completing the osteosynthesis, d) intraoperative photo after completing the osteosynthesis with maximum knee flexion.

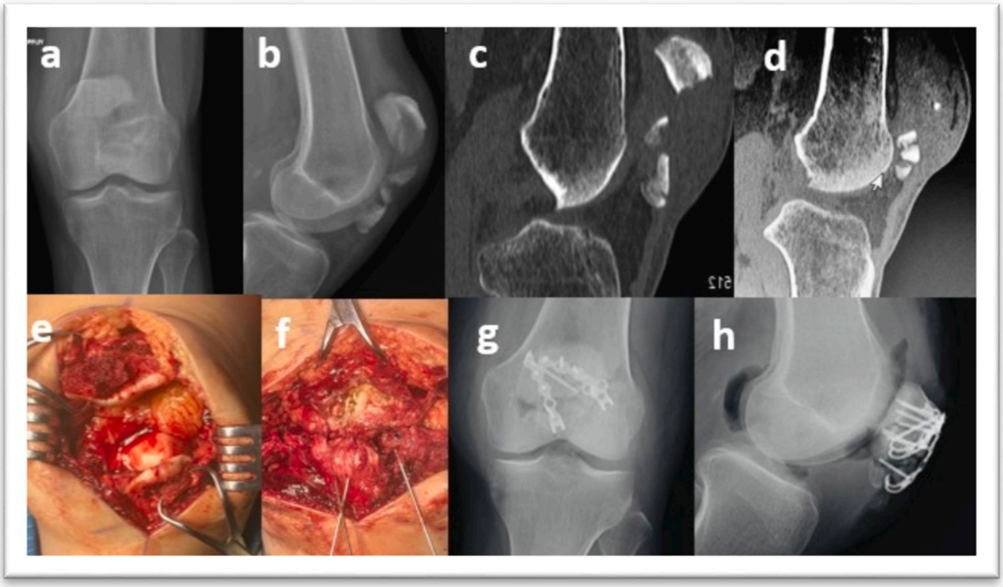

Fig. 3. Case 3: a and b); preoperative anteroposterior and lateral radiographs of the left knee, c and d); computed tomography of the left patella showing multifragmentation, e); intraoperative photographs of the left multifragmentary patellar fracture, f); intraoperative photographs of the multifragmentary patellar fracture, provisional fixation with Kirschner wires, g and h); immediate postoperative anteroposterior and lateral radiographs of the left knee.

Table 1
Patient characteristics based on age, affected side, classifications and time of follow up in months.

Patient	Age	Side	AO classification	CT classification (morphological characteristics)	Time of follow up (months)
1	15	Bilateral	C3	IV	30
2	83	Right	C2	IV	12
3	53	Left	C3	III B	18

procedures, including interventions for articular cartilage restoration, meniscus repairs or transplants, osteotomies, patellar osteosynthesis, or patellofemoral procedures. In this case, it was applied to assess patients' perceptions of knee functionality after osteosynthesis and upon reintegrating into their daily activities (Table 2).

The evaluation system comprised multiple components, including a physical examination, stability tests, and radiographic observations. Over time, it had undergone various modifications and expansions to assess symptoms and functional limitations in sports and daily activities. In its modified version, the CKRS consisted of 13 scales and six subscales addressing symptoms (20 points), sports and daily activities (15 points), physical examination (25 points), knee instability assessment (20 points), radiographic findings (10 points), and functional tests (10 points). The total score ranged from 0 to 100 points. Despite its utility, common criticisms focused on the time required for completion and a certain level of associated complexity.

Fig. 4. Follow-up of Case 1: a and b); 30 months postoperative anteroposterior and lateral radiographs of the left knee, c and d); 30 months postoperative anteroposterior and lateral radiographs of the right knee.

Fig. 5. Follow-up of Case 2: a, b, and c); 2 weeks postoperative anteroposterior, lateral, and axial X-ray of the right knee, the axial X-ray of the patella to verify stability and non-invasion of the patellar articular surface, d and e); twelve months postoperative anteroposterior and lateral axial X-ray of the right knee.

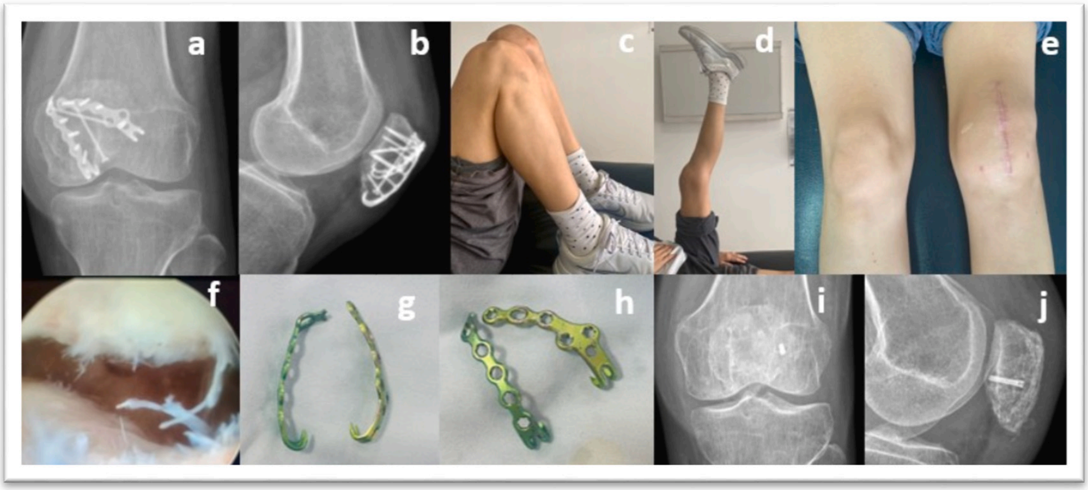

Fig. 6. Follow-up of Case 3: a and b); one-year postoperative anteroposterior and lateral radiographs of the left knee, c); comparison of flexion between the left (operated) and right (healthy) knees one month post-implant removal, d); active extension of the left knee one month post-implant removal, e); clinical appearance of the wound after implant removal, f); intraoperative arthroscopy photograph with one year of evolution, showing Grade III Chondromalacia of the patella and femoral trochlea, g and h); Molded hook plate for the fifth metatarsal, i and j); postoperative anteroposterior and lateral radiographs after implant removal, showing the Acutrak screw that could not be removed as it was left intra-fracture.

Table 2
Cincinnati Knee Rating System (CKRS) evaluation for the three documented cases.

Patient	Pain	Swelling	Steps	Activity level	Walking	Stairs	Running	Jumping	Total
1	16	10	20	20	10	10	5	5	96
2	20	8	20	16	10	10	5	4	93
3	8	4	16	12	8	8	3	3	62

The comprehensive evaluation using the CKRS allowed us to assess the overall recovery of patients 1 and 2 thoroughly. For these patients, it was evident that they had not experienced limitations after undergoing osteosynthesis using the described technique.

In the case of patient number 3, due to their age, the recovery process was slightly more complex. Nevertheless, the scale results indicated that the patient had achieved functionality for carrying out daily activities. It was important to note that the values for this patient were not directly comparable to those of the other cases, as the recovery process may take longer due to the patient's age. However, osteosynthesis had proven to be successful, allowing the patient to regain their quality of life.

Discussion

The technique of cerclage and/or tension band has been traditionally employed to treat displaced fractures that had the capacity to withstand compression, with an intact opposite cortex and a fixation capable of supporting traction forces [14,16,18,23]. However, in the case of multi-fragmentary fractures that did not meet these requirements, unfavorable results have been reported when using this fixation method [7]. Bostman et al. [28] described that as the fracture became multi-fragmentary and the patient's age increased, results with cerclage and/or tension band tended to deteriorate. Smith et al. [29] reported that 22% of patellar fractures treated with cerclage and/or tension band experienced displacement, and osteosynthesis failed before the fracture could consolidate, especially in the case of multi-fragmentary fractures in older patients with osteoporotic bones.

Despite the technical adaptations made to cerclage or tension band, Lazaro LE et al. [6] reported that early fixation failure rates could range between 22% and 30% of cases. In a detailed biomechanical study by Thelen S. et al. [30], three fixation methods were compared (bilateral fixed-angle plate, modified anterior tension wiring, and cannulated traction screws with anterior tension wiring) in multi-fragmentary fractures of the distal patella. Following osteosynthesis, repetitive tests were conducted for 100 cycles of knee movement against gravity, from 90° flexion to 0° extension, defining "osteosynthesis failure" as a displacement of 2 mm during or after the mentioned cyclic tests. The study demonstrated that fixed-angle plates were able to maintain the reduction of fractures, while anterior tension wires and traction screws with tension wires exhibited significant displacement.

In a biomechanical study conducted by Wagner FC et al. [31], osteosynthesis with an anterior locking plate was compared with cannulated screws with tension band wiring in comminuted patellar fractures. The results indicated that plates provided better primary stability in this context.

Subsequently, Alley MC et al. [24] used an anterior hook plate in 51 patients, addressing both simple transverse fractures and comminuted patellar fractures. In the biomechanical study involving thirty-six cadaveric patellae, it was demonstrated that the dorsal plate is biomechanically and clinically superior to cerclage and modified tension band techniques in comminuted patellar fractures.

On the other hand, Tsotsolis S. et al. [31] reported a 10.44% complication rate associated with the use of plates for patellar fractures, a lower figure compared to osteosynthesis with cerclage. Cerclage fixation combined with hook plate, according to Gu et al. [22], has been revealed as a reliable method for managing fractures of the lower patellar pole, allowing immediate rehabilitation and weight-bearing.

Given the absence of a suitable classification for lower pole patellar fractures, Liu et al. [7] proposed a classification based on the morphological characteristics of the fracture. This approach, developed after studying CT images in 71 patients, allows for the determination of an individualized treatment protocol for each type of fracture.

Conclusions

Within the scope of our research, the first description of osteosynthesis for multi-fragmentary patellar fractures using a locked anatomical hook plate designed for the fifth metatarsal was presented. This innovative technique anatomically adapts to the structure of the patella, achieving stable fixation and allowing for early initiation of physiotherapy. The absence of implant failures or loosening during the fracture consolidation period is highlighted, contributing to a reduction in associated complications such as knee stiffness and irritation or intolerance to the presence of the subcutaneous implant.

Our experience, although based on a limited number of cases due to the low frequency of these fractures, has revealed promising clinical and radiological results. This fact encourages us to continue employing this technique and possibly consider its application in a broader context in the future.

An aspect to consider is the cost associated with the use of the fifth metatarsal hook plate compared to traditional methods. While it is acknowledged that this option may have a higher initial cost, it is crucial to consider additional costs related to possible re-operations in cases of cerclage and tension band failure. This economic analysis suggests that, in the long run, the potential benefits of the technique could balance or even reduce the overall treatment costs for multi-fragmentary patellar fractures.

However, we recognize that our conclusion is based on a limited number of cases, and we suggest that future studies with a larger sample be conducted for a more detailed analysis of the costs and benefits associated with the use of this innovative technique.

CRediT authorship contribution statement

Edgar Alejandro Barros: Writing – original draft, Validation, Supervision, Project administration, Data curation, Conceptualization. **Carlos Ballesteros:** Conceptualization, Data curation. **Carlos Eduardo Noboa:** Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization. **Gonzalo Arteaga:** Formal analysis, Conceptualization. **Carlos Peñaherrera:** Writing – review & editing, Conceptualization. **Francisco Endara:** Writing – review & editing, Data curation. **Andrés Bravo:** Writing – review & editing. **Alejandro Xavier Barros Castro:** Writing – review & editing, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare no conflict of interest.

References

[1] T.P. Van Staa, E.M. Dennison, H.G. Leufkens, C. Cooper, Epidemiology of fractures in England and Wales, Bone 29 (6) (2001) 517–522, https://doi.org/10.1016/S8756-3282(01)00614-7 (PubMed).
[2] Bostrom A. Fracture of the patella. A study of 422 patellar fractures. Acta Orthop Scand Suppl. 1972;43(sup143):1–80. doi: doi: https://doi.org/10.3109/ort.1972.43.suppl-143.01. PubMed.
[3] Sayum Filho J, Lenza M, Teixeira de Carvalho R, Pires OG, Cohen M, Belloti JC. Interventions for treating fractures of the patella in adults. Cochrane Database Syst Rev. 2015;2(2):. doi: doi:https://doi.org/10.1002/14651858.CD009651.pub2. (PubMed).
[4] Gosal HS, Singh P, Field RE. Clinical experience of patellar fracture fixation using metal wire or non-absorbable polyester—a study of 37 cases. Injury 2001;32 (2):129–35. doi: https://doi.org/10.1016/S0020-1383(00)00170-4 (PubMed).
[5] A. Matejčić, M. Ivica, D. Jurišić, T. Ćuti, B. Bakota, D. Vidović, Internal fixation of patellar apex fractures with the basket plate: 25 years of experience, Injury 46 (Suppl. 6) (Nov 2015) S87–S90, https://doi.org/10.1016/j.injury.2015.10.068 (Epub 2015 Nov 14. PMID: 26584729).
[6] L.E. Lazaro, D.S. Wellman, N.C. Pardee, M.J. Gardner, J.B. Toro, N.R. Macintyre 3rd, et al., Effect of computerized tomography on classification and treatment plan for patellar fractures, J. Orthop. Trauma 27 (6) (2013) 336–344, https://doi.org/10.1097/BOT.0b013e318270dfe7 (PubMed).
[7] C.D. Liu, S.J. Hu, S.M. Chang, S.C. Du, Y.Q. Chu, Morphological characteristics and a new classification system of the inferior pole fracture of the patella: a computer-tomography-based study, Injury (2023) 111256, https://doi.org/10.1016/j.injury.2023.111256 (Advance online publication).
[8] J.S. Melvin, S. Mehta, Patellar fractures in adults, J. Am. Acad. Orthop. Surg. 19 (4) (2011) 198–207, https://doi.org/10.5435/00124635-201104000-00004 (PubMed).
[9] K. Atesok, M.N. Doral, J. Lowe, A. Finsterbush, Symptomatic bipartite patella: treatment alternatives, J. Am. Acad. Orthop. Surg. 16 (8) (2008) 455–461, https://doi.org/10.5435/00124635-200808000-00004 (PubMed).
[10] Q.F. He, G.B. Pan, Z.F. Yu, W.X. Yao, L.L. Zhu, C.F. Luo, X.S. Guo, Novel rim plating technique for treatment of the inferior pole fracture of the patella, Orthop. Surg. 13 (2) (Apr 2021) 651–658, https://doi.org/10.1111/os.12876 (Epub 2021 Feb 22. PMID: 33619908; PMCID: PMC7957411).
[11] C. Gwinner, S. Märdian, P. Schwabe, K.D. Schaser, B.D. Krapohl, T.M. Jung, Current concepts review: fractures of the patella, GMS Interdiscip Plast Reconstr Surg DGPW 5 (Jan 18 2016) Doc01, https://doi.org/10.3205/iprs000080 (PMID: 26816667; PMCID: PMC4717300).
[12] Buckley R., Moran Ch., Apivatthakakul T. AO Principles of Fracture Managemen Third Edition, 853–864, 2017.
[13] M. Muller, M. Allgower, R. Schneider, H. Willenegger, Manual of Internal Fixation: Techniques Recommended by the AO-ASIF Group, 3rd edition, Springer-Verlag, Berlin, 1991.

[14] O. Baran, M. Manisali, B. Cecen, Anatomical and biomechanical evaluation of the tension band technique in patellar fractures, Int. Orthop. 33 (4) (2009) 1113–1117, https://doi.org/10.1007/s00264-008-0602-3 (PubMed).

[15] Fortis AP, Milis Z, Kostopoulos V, Tsantzalis S, Kormas P, Tzinieris N, et.al. Experimental investigation of the tension band in fractures of the patella. Injury 2002;33(6):489–93. doi: https://doi.org/10.1016/S0020-1383(01)00173-5 (PubMed).

[16] L. Camarda, A. La Gattuta, M. Butera, F. Siragusa, M. D'Arienzo, Fiber-wire tension band for patellar fractures, J. Orthop. Traumatol. 17 (1) (2016) 75–80, https://doi.org/10.1007/s10195-015-0359-6.

[17] M.J. Gardner, M.H. Griffith, B.D. Lawrence, D.G. Lorich, Complete exposure of the articular surface for fixation of patellar fractures, J. Orthop. Trauma 19 (2) (2005) 118–123, https://doi.org/10.1097/00005131-200502000-00008 (PubMed).

[18] C.M. Hoshino, W. Tran, J.V. Tiberi III, M.H. Black, B.H. Li, S.M. Gold, et al., Complications following tension-band fixation of patellar fractures with cannulated screws compared with Kirschner wires, J. Bone Joint Surg. Am. 95 (7) (2013) 653–659, https://doi.org/10.2106/JBJS.K.01549.

[19] M.P. Siljander, A.D. Vara, D.M. Koueiter, B.P. Wiater, P.J. Wiater, Novel anterior plating technique for patella fracture fixation, Orthopedics 40 (4) (Jul 1 2017) e739–e743, https://doi.org/10.3928/01477447-20170615-02 (Epub 2017 Jun 21. PMID: 28632289).

[20] M. D'Ambrosio, A. Tang, L. Menken, A.T. Hagag, F.A. Liporace, R.S. Yoon, Adjunct neutralization plating in patella fracture fixation: a technical trick, OTA Int. 5 (4) (Oct 13 2022) e217, https://doi.org/10.1097/OI9.0000000000000217 (Erratum in: OTA Int. 2023 Mar 13;6(2):e265. PMID: 36569111; PMCID: PMC9782314).

[21] H. Gu, S. Zhu, T. Li, X. Wu, Combination of cable cerclage and hook plate for the fixation of comminuted fractures of inferior patellar pole: a review of 16 consecutive patients followed up for a minimum of 1 year, Orthop. Surg. 14 (11) (Nov 2022) 3111–3118, https://doi.org/10.1111/os.13481 (Epub 2022 Oct 7. PMID: 36208008; PMCID: PMC9627067).

[22] J.H. Jang, S.J. Rhee, J.W. Kim, Hook plating in patella fractures, Injury 50 (11) (Nov 2019) 2084–2088, https://doi.org/10.1016/j.injury.2019.08.018 (Epub 2019 Aug 15. PMID: 31445832).

[23] M.C. Alley, M. Kain, S. Mitchell, B.J. Walker, C.B. Jones, P. Tornetta 3rd., Anterior hook plating of patella fractures: a biomechanical analysis and clinical series, J. Orthop. Trauma 37 (6) (Jun 1 2023) e258–e263, https://doi.org/10.1097/BOT.0000000000002565 (PMID: 36728234).

[24] Hargett, Damayea I. MD; Sanderson, Brent R. DO; Little, Milton T.M. MD. Patella fractures: approach to treatment. Journal of the American Academy of Orthopaedic Surgeons 29(6):p 244–253, March 15, 2021. | DOI: https://doi.org/10.5435/JAAOS-D-20-00591.

[25] M.P. Bostrom, S.E. Asnis, J.J. Ernberg, T.M. Wright, V.L. Giddings, W.S. Berberian, A.A. Missri, Fatigue testing of cerclage stainless steel wire fixation, J. Orthop. Trauma 8 (5) (Oct 1994) 422–428, https://doi.org/10.1097/00005131-199410000-00009 (PMID: 7996326).

[26] D.L. Helfet, N.P. Haas, J. Schatzker, P. Matter, R. Moser, B. Hanson, AO philosophy and principles of fracture management-its evolution and evaluation, J. Bone Joint Surg. Am. 85 (6) (2003) 1156–1160, https://doi.org/10.2106/00004623-200306000-00029 (PubMed).

[27] O. Böstman, O. Kiviluoto, J. Nirhamo, Comminuted displaced fractures of the patella, Injury 13 (3) (Nov 1981) 196–202, https://doi.org/10.1016/0020-1383(81)90238-2 (PMID: 7327739).

[28] S.T. Smith, K.E. Cramer, D.E. Karges, J.T. Watson, B.R. Moed, Early complications in the operative treatment of patella fractures, J. Orthop. Trauma 11 (3) (Apr 1997) 183–187, https://doi.org/10.1097/00005131-199704000-00008 (PMID: 9181501).

[29] S. Thelen, M. Betsch, J. Schneppendahl, J. Grassmann, M. Hakimi, C. Eichler, J. Windolf, M. Wild, Fixation of multifragmentary patella fractures using a bilateral fixed-angle plate, Orthopedics 36 (11) (Nov 2013) e1437–e1443, https://doi.org/10.3928/01477447-20131021-29 (PMID: 24200450).

[30] F.C. Wagner, M.V. Neumann, S. Wolf, A. Jonaszik, K. Izadpanah, S. Piatek, N.P. Südkamp, Biomechanical comparison of a 3.5 mm anterior locking plate to cannulated screws with anterior tension band wiring in comminuted patellar fractures, Injury 51 (6) (Jun 2020) 1281–1287, https://doi.org/10.1016/j.injury.2020.03.030 (Epub 2020 Mar 17. PMID: 32197829).

[31] S. Tsotsolis, J. Ha, A.R.C. Fernandes, J.Y. Park, M. Dewhurst, T. Walker, K. Ilo, S.R. Park, A. Patel, T. Hester, F. Poutoglidou, To plate, or not to plate? A systematic review of functional outcomes and complications of plate fixation in patellar fractures, Eur. J. Orthop. Surg. Traumatol. (Jun 7 2023), https://doi.org/10.1007/s00590-023-03597-9 (Epub ahead of print. PMID: 37286819).