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REVIEW

The management of nonunion and delayed union of patella fractures: a systematic review of the literature

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Abstract Nonunion and delayed union of patella fractures are rare conditions that are fraught with challenges. There exists limited evidence in the literature to guide the clinician in the management of these complications. Therefore, the purpose of this study was to perform a systematic review of the available evidence on the management of nonunion and delayed union of patella fractures. A total of five publications which met our criteria were identified and formed the basis of this study. The decision making in the treatment of this condition is based on the functional demands of the patient, the factors that led to the development of the nonunion, the potential impact of the biomechanical effects of a total patellectomy, and the presence of an intact extensor mechanism of the knee for a later reconstructive procedure. Patients with low functional demands may be managed with nonoperative methods; however, those who perform heavy physical work or participate in sports usually require open reduction and internal fixation. Tension band wiring is the treatment of choice for patients suitable for a reconstructive procedure. Partial or total patellectomy is also an option for small distal fragments or an inability to satisfactorily perform internal fixation.

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Introduction

The incidence of nonunion or delayed union of patella fractures is rare and ranges from 2.7–12.5% [1] (Table 1). The treatment of this complication is fraught with several challenges. The decision making in the treatment of this condition is based on the functional demands of the patient, the factors that led to the development of the nonunion, the potential impact of the biomechanical effects of a total patellectomy, and the presence of an intact extensor mechanism of the knee for later reconstructive procedure. Thus, the decision to perform surgery to improve the quality of life based upon repairing the nonunion or excising the patella is difficult and requires an evidence-based approach.

To our knowledge, there is limited evidence to guide clinicians on the management of nonunion or delayed union of patella fractures. Therefore, the purpose of this study was to perform a systematic review of the available evidence on management of this complication with specific reference to patient demographics, mechanism, mode of presentation, risk factors, definitive treatment, and functional outcomes.

Materials and methods

An Internal Review Board-exempt study was undertaken at a University-based level I trauma centre. A PubMed, EMBASE, CINHal, and OVID Medical database search was conducted with the title query: patella fracture, nonunion, delayed union, conservative treatment, open reduction and internal fixation, patellectomy and bone grafting. One author selected high yield abstracts and obtained full articles for the review. Search terms included patella fracture, nonunion, delayed union, conservative treatment, open reduction and internal fixation, patellectomy,

Table 1 Incidence of patella fracture nonunion and delayed union

Author	Year	Number of patients	Nonunion and delayed union
Sorensen [11]	1964	64	8 (12.5%)
Nummi [10]	1971	355	17 (4.78%)
Bostrom [6]	1974	246	21 (8.54%)
Torchia and Lewallen [5]	1995	28	2 (7.14%)
Klassen and Trousdale [1]	1997	736	20 (2.7%)
Mehdi et al. [12]	1999	203	8 (4%)
Uvaraj et al. [4]	2007	88	22 (25%)

and bone grafting. The criteria for inclusion were patella fractures and case series of patella nonunion and delayed union treated conservatively or surgically with conventional methods of fixation. Exclusion criteria included single case reports, pathological fractures, and paediatric fractures.

Results

A total of five publications [1–5] were identified and formed the basis of this study.

Gender and age

All five studies indicated that the incidence of delayed and nonunion was more common in males than females. Of 45 patients, 31 (68.8%) were male and 14 (31.2%) were female. The average patient age was 38 years (range, 27–48 years).

Mechanism of injury

The most common mechanism of injury for the patella fractures was a fall onto the knee in 24 patients (57.1%), a motor vehicle accident in 15 (35.7%), and a sports injury in three (7.2%) [1, 4]. All studies discussed the initial mechanism of injury and fracture pattern in detail. All of the initial patella fractures were classified based on the anatomical location of the fracture line. There were four (9.5%) upper pole fractures, 25 (59.6%) transverse fractures, three (7.2%) vertical fractures, six (14.2%) comminuted fractures, and four (9.5%) lower pole fractures [1, 4]. One study did not clearly describe the patella fracture or the type of initial fracture [3]. Only one study mentioned whether the injury was closed or open [5].

Mode of presentation

Nearly all patients who developed nonunion or delayed union were treated with some form of splinting. Three studies reported that the average time between the injury and presentation ranged from two to 34 months [1, 3, 4]. The predominant symptoms were weakness and frequent giving-way of the injured knee. There were also limitations in climbing stairs and restriction of knee motion, with an average range of preoperative knee motion of 10–110°. Clinically, a nonunion of the patella was obvious, with the gap between the fragments ranging from 4 to 8 cm.

Definitive treatment

The definitive treatment of nonunion and delayed union was either nonoperative or operative. The nonoperative management consisted of observation, activity modification, physical therapy, and local pain relieving measures. Surgical treatment included open reduction and internal fixation, partial patellectomy, and patellectomy. The modes of internal fixation included tension band wiring, cerclage wiring, Bunnell wiring, and screw fixation. The predominant modality of internal fixation was a standard tension band wiring, which was used in 25 patients (65.7%) [1, 3, 4]. None of the patients required a quadricepsplasty for reduction of the fracture fragments. There was no correlation between the duration of delay in presentation and ability to attain adequate reduction [5]. Two patients in one study underwent bone grafting during open reduction and internal fixation [3].

Functional outcomes

None of the nonunions treated by nonoperative methods had radiographic union [1]. The functional outcomes were discussed in detail based on a scoring system in two studies [1, 4], while the others based their outcome on the clinical satisfaction of the patients. One study [1] used the Knee Society knee and function scores to evaluate the end result, while another study used the Bostam knee score as an outcome measurement [4]. Patients who had surgery had an average Knee Society score of 94, functional score of 93, and an average amount of knee motion of 109°. The outcome of the study using the Bostam knee score was excellent in five patients, good in 15 patients, and poor in two patients. The complications noted following internal fixation were infection in three patients (7.8%) and hardware-related complications in two (5.2%). One patient who had infection had a

persistent nonunion. One patient who had a refracture two years after the initial treatment for patellar nonunion following an acute trauma was not considered a complication of the patella nonunion treatment by the authors [1]. Two patients in one study [5] who had infections developed severe postoperative stiffness.

Discussion

The functional significance of restoring the extensor mechanism with the preservation of the patella is well documented following fracture of the patella. There is abundant evidence on the operative management of patella fractures in the literature. A PubMed search with the key words "patella fracture" yielded 1,283 hits and EMBASE search with key words "patella fracture" yielded 1,455 hits. In contrast, the treatment of patella nonunion and delayed union is a challenging problem with limited evidence in the literature regarding the management protocol. In addition, there are no current procedural terminology (CPT) billing codes for surgical procedures for patella nonunion or delayed union. Because this complication is rare, it presents a unique dilemma to the surgeon on whether to preserve the entire patella or perform a salvage procedure such as a patellectomy. This study attempted to review the available evidence to formulate a treatment protocol for the management of nonunion and delayed union of patellar fractures.

In a series of 246 fractures followed up after conservative treatment, Bostrom [6] reported no pain or discomfort in 89% and normal or slightly impaired function in 91%. The range of motion was 0–120° in more than 90%. Operative management in the form of open reduction and internal fixation, partial patellectomy, and patellectomy has been the mainstay of treatment.

Preservation of the patella was described as early as 1919 [7]. The preservation of the patella is deemed necessary due to the problems reported following patellectomy, including the loss of 18° or more of knee motion, instability of the knee, a 49% reduction in the strength of the extensor mechanism, and a reduction in stance phase flexion excursion in both level walking and stair climbing [8]. Kaufer [9] reported that following patellectomy, extending the knee required a 30% increase in quadriceps force. This increase in quadriceps force may be beyond the capacity of some patients, particularly those with long-standing intra-articular disease, advanced age, high activity demands, and an extensor lag before surgery. Anterior tension band wiring appears to restore excellent functional integrity in approximately 86% of patients with very low complication rates [2, 10]. The complications most commonly reported were infection, loss of motion, hardware-related problems, refracture, and delayed union or nonunion.

Most patients with low functional demands with patellar nonunion or delayed union are able to manage their activities of daily living with few symptoms. However, they have difficulty with heavy work or sports activities, as most experience weakness and frequent giving-way of the affected knee. They have difficulty climbing stairs, as they tend to adapt a gait pattern in which they rotate the lower limb internally and stabilise the knee in an extended position. The decision of whether to retain the patella, a time-tested principle in preserving the integrity of extensor mechanism, or to perform a patellectomy (partial or total) is open to continued debate for these patients.

The risk factors for the development of nonunion or delayed union of patellar fractures are not clearly defined. However, there appear to be certain factors which are more frequently associated including open fractures, transverse fractures, and immobilisation during conservative fracture management. Strong correlations exist between open fractures and the development of nonunion. Torchia and Lewallen [5] reported two patients (7%) who developed nonunion among the 28 patients who underwent open reduction and internal fixation for open patella fractures. Klassen and Trousdale [1] reported four of 19 patients (21%) had open fractures. Open fractures of the patella occur from high-energy trauma and result in high grade soft tissue injury, disruption of the extensor mechanism, and injury to the patellofemoral articular cartilage. The mechanism is most likely a direct compressive force on the knee or indirect tensile forces. In open fractures of the patella various factors may lead to nonunion or delayed union.

Among the various fracture configurations, transverse fractures of the patella were commonly associated with the development of nonunion. Forces that act primarily at the fracture site are predominantly distraction forces that occur during the physiological activity of the quadriceps. The angle between the quadriceps and the patellar tendon force across a flexed knee tends to produce a more distractive force by creating a bend at the site of the fracture. Approximately 60% of initial fracture presentations were transverse fractures. Satku and Kumar [3] and Uvaraj et al. [4] noted that approximately 90% of their patients had undergone traditional treatment in the form of splints for the initial fracture. Inadequate is a well-recognised cause of impairment of fracture healing. Information regarding the amount of initial fracture displacement was not recorded in most of the studies; therefore, the risk of non-union and delayed union relative to the amount of fracture fragment displacement could not be ascertained.

Satku and Kumar [3] noted that following mobilisation and anterior tension band wiring of the fragments, additional fixation was required. A tension loop between the proximal fragment and the tibia was used to protect the

anterior tension band over the patella during mobilisation of the knee. They also noted a low-lying patella in two of three cases two years postoperatively. The theoretical cause of a low-lying patella (patella baja or infera) is a shortening of the patellar tendon over time which alters the biomechanics of the knee. Providing supplementation fixation in the region of the patellar tendon may act as an internal bracing during the initial rehabilitative period, but may also act as a compressive force that shortens an already contracted patellar tendon.

Klassen and Trousdale [1] reported mean Knee Society and function scores of 72 and 78 points, respectively, with an average range of knee motion of 127° in patients with nonunion treated conservatively. Patients treated operatively improved their mean Knee Society score from 82 to 94 points, and improved their function scores from 80 to 93 points. However, the average knee motion decreased from 112° to 109°. Patients who had operative management or elective nonoperative management performed better than those who refused operative treatment. All patients who were treated nonoperatively had persistent radiographic nonunion as did one patient who underwent open reduction and internal fixation.

Uvaraj et al. [4] noted excellent to good results based on the Bostman criteria in 20 of 22 patients who underwent operative fixation of the patella fracture nonunion and delayed union. Two patients had poor results due to infection, implant failure, and loss of motion. These authors reported difficulty in reduction in most of their patients that was resolved with an initial cerclage wiring followed by anterior tension band wiring. The cerclage wire was removed after application of the tension band in most patients. None of the patients required quadricepsplasty for mobilisation of the fragments.

Partial or total patellectomy may be required when the patella is not salvageable. Klassen and Trousdale [1] reported the need for partial or total patellectomy when the fracture pattern or fragment size made internal fixation impossible.

No specific recommendation regarding the use of bone grafts exists in literature. Klassen and Trousdale [1] reported bone grafting in two patients, but did not provide background information for their indications. Bone grafting options may be considered on a case-by-case basis for nonunion and delayed union of patella fractures.

The algorithm shown in Fig. 1 outlines our proposed protocol for clinical management of this condition. The

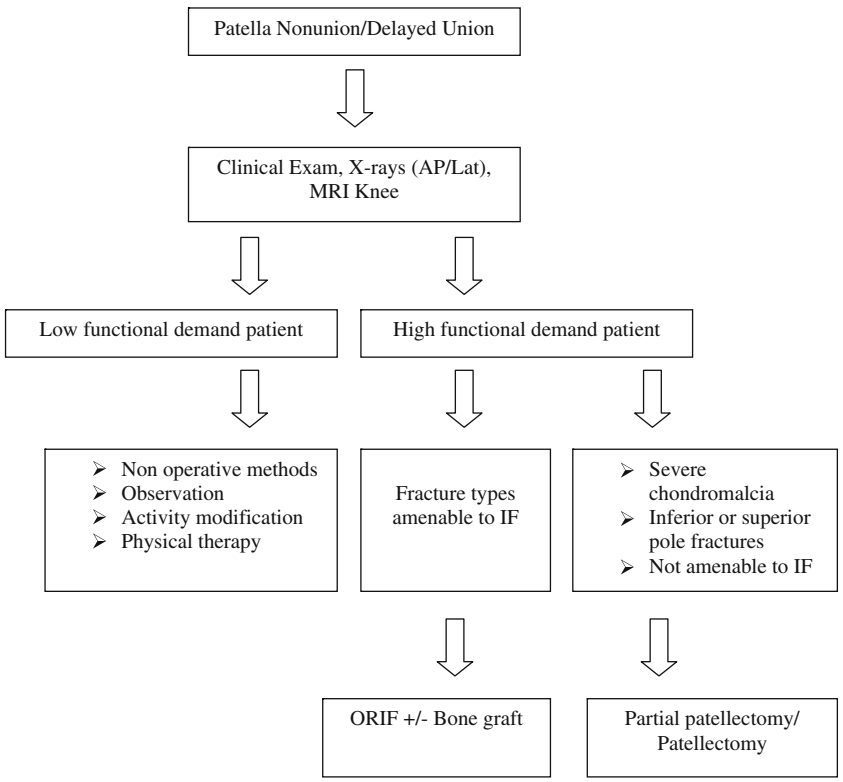

Fig. 1 Algorithm for the management of patella fracture nonunion and delayed union

AP- Anteroposterior
Lat - Lateral
MRI - Magnetic Resonance Imaging
IF - Internal fixation
ORIF -Open reduction and internal fixation

decision making in the treatment of patella fracture nonunion or delayed union is based on the functional demands of the patient, the factors that led to the development of the nonunion, the potential impact of the biomechanical effects of a total patellectomy, and the presence of an intact extensor mechanism of the knee for a later reconstructive procedure.

The incidence of osteoarthritis after nonunion and delayed union of patella fractures is debatable. Sorensen [11] noted the risk of patellofemoral osteoarthritis of the affected knee appeared to be similar following either nonoperative or operative fracture management. Bostrom [6] noted that there was no increase in the frequency of osteoarthritis of the patellofemoral joint due to nonunion, delayed union, and enlargement of the patella. This author also noted osteoarthritis was higher in those with a step in the articular surface of the patella of 1 mm or more as compared to other patients. The development of osteoarthritis primarily depends on the amount of cartilage damage that occurs during the initial injury and the presence of a step of more than 1 mm of the articular surface of the patella. Mehdi et al., in a series of 203 cases of patella fracture treated with tension band wiring, reported 8.5% (17 of 203 patients) of patients developed patellofemoral arthritis [12].

A major limitation of this study was the variation in treatment strategies employed by surgeons without clear criteria, including the indications for the choice of internal fixation. Therefore, the types of fixation could not be qualitatively compared. There was also limited evidence that precluded recommendations or indications for bone grafting in nonunion and delayed union of patella fractures.

Conclusion

Nonunion and delayed union of fractures of the patella are uncommon. However, certain factors exist such as open fractures, improper immobilisation, and the initial fracture configuration which may raise surgeon vigilance and create the need for management strategies to prevent future nonunion and delayed union. Patients with low functional demands may be managed with nonoperative methods; however, those who perform heavy physical work or participate in sports usually require open reduction and internal fixation. Operative management appears to play a major role in restoring the functional integrity of the extensor mechanism. Tension band wiring is the treatment of choice for patients suitable for a reconstructive procedure. Partial or total patellectomy is also an option for small distal fragments or where satisfactory internal fixation cannot be achieved. There is a need for prospective, multicentre studies to add to the limited available evidence regarding the management of nonunion and delayed union of patella fractures.

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