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ORIGINAL ARTICLE–ORTHOPEDICS

Ultrasound-guided injection and the pie crust technique for the treatment of symptomatic bipartite patella

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Abstract

Purpose This study aimed to investigate the results of a new treatment procedure (ultrasound-guided injection and the "pie crust" technique for lengthening of capsular tendon structures) for symptomatic bipartite patella.

Methods We retrospectively investigated patient outcomes following the treatment of symptomatic type III bipartite patella with our new technique. Fifteen knees in 14 boys (mean age, 13.0 ± 1.7 years) were included. The procedure involved the injection of 1% lidocaine (2 mL) and triamcinolone acetonide (5 mg) between the patella and fragment. We then punctured 10 sites from one skin puncture to extend lateral capsular tendon structures. The patients were clinically assessed using the Victorian Institute of Sports Assessment (VISA) score before and 1 week, 1 month, and 3 months after the procedure. Patients were also evaluated for complications.

Results The average VISA score was 45.7 ± 4.7 before treatment, 70.6 ± 7.3 at 1 week post-treatment, 84.4 ± 16.6 at 1 month post-treatment, and 88.6 ± 18.3 at 3 months post-treatment. The VISA score improvement from before the procedure to 1 week after the procedure was significant ($P < 0.01$). There were no complications in any of the patients, who returned to sports at a mean of 4.2 ± 2.1 weeks after the procedure. However, two patients (three knees) had poor results and could not return to action; thus, they underwent surgical treatment 4 months after the ultrasonographic procedure.

Conclusions This novel method is a potential treatment option for the management of symptomatic bipartite patella in outpatient clinics.

Keywords Bipartite patella · Ultrasound-guided injection · Pie crust technique

Introduction

The patella develops initially as an expanding mass of cartilage, with ossification beginning between the ages of 3 and 5 years and continuing until 9–10 years [1]. In most cases, multiple small foci combine to form a central nidus, with a single ossification center being seen in 77% of children, and two or three centers being seen in the remainder [2]. Usually, these centers unite to form a continuous subchondral plate.

However, the unification of ossification centers can fail to occur, resulting in a bipartite patella with a fibrocartilaginous union between the bipartite fragment and patella body [3]. Bipartite patellae can be classified as follows based on the position of the accessory ossification center [4]: type I (5%), transverse split with the accessory center at the inferior pole; type II (20%), longitudinal split with the accessory center at the lateral margin; and type III (75%), accessory center at the superolateral pole. Regardless of classification, the condition is usually asymptomatic and is considered an anatomical variant of the knee present in 1–2% of the healthy population [5]. However, in patients who are symptomatic, the onset of pain typically occurs between 12 and 14 years of age due to sports participation, as reported by Oohashi et al. [6]. These authors also reported that out of 50 knees in patients with symptomatic bipartite patella, only 6% experienced knee pain during walking.

Initial management of a painful bipartite patella is nonsurgical and includes restriction of activities, immobilization and bracing, administration of nonsteroidal anti-inflammatories, physical therapy, and local corticosteroid

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injections [7, 8]. If conservative management fails and symptoms linger, surgical treatment may be warranted. Surgical methods that have been described include excision of the fragment, soft tissue procedures such as lateral retinacular release [9] and vastus lateralis release [10], and open reduction and internal fixation of the painful fragment [11]. Although good results have been reported with these procedures, there are many athletes and families who hesitate to undergo surgical treatment. Therefore, we developed a new treatment that can be performed in an outpatient clinic under local anesthesia.

We hypothesized that ultrasound-guided injection and the pie crust technique would be an effective and safe treatment option for symptomatic type III bipartite patella. We examined whether surgical treatment could be avoided in patients who planned to undergo surgical treatment after ineffective conservative treatment. The purpose of this study was therefore to investigate patient outcomes following the performance of ultrasound-guided injection and the pie crust technique for the treatment of symptomatic type III bipartite patella, and determine the effectiveness and safety of the novel technique.

Materials and methods

We performed ultrasound-guided injection and the pie crust technique on 15 knees in 14 male patients (mean age, 13.0 ± 1.7 years) between August 2017 and September 2018. The inclusion criteria were as follows: clinically symptomatic type III bipartite patella confirmed by radiography, ultrasonography, and computed tomography, with conventional conservative therapy (i.e., restriction of activities, immobilization, administration of nonsteroidal anti-inflammatories, and physical therapy) being ineffective for more than 2 months. The exclusion criteria were a history of previous knee surgery and severe degenerative changes of the patellofemoral joint. Patients with less than 4 months of follow-up were also excluded.

Patient assessment

Patients were clinically assessed using the Victorian Institute of Sports Assessment (VISA) score (a scoring system in which higher scores indicate better clinical outcomes) [12] before and 1 week, 1 month, and 3 months after ultrasound-guided injection and the pie crust technique were performed. The occurrence of complications (i.e., infection, severe pain, and hematoma) was also investigated during the follow-up period.

Ultrasound-guided injection and the pie crust technique

Diagnostic ultrasound was performed using the SONIMAGE HS-1 ultrasound system (Konica Minolta Healthcare, Tokyo, Japan) with a linear transducer (18–4 MHz). Ultrasound-guided injection and the pie crust technique were performed by a single knee surgeon (J.N.) in an outpatient clinic. The patient was placed in the supine position with the knee slightly flexed to approximately 10° and supported by a pillow (Fig. 1). The skin was then cleansed with povidone iodine, after which a 19-mm 27-gauge needle was used to administer 3 mL of 1% lidocaine for local anesthesia. Then, a 25-mm 25-gauge needle was guided into the knee from a lateral approach using a short-axis view of the patella to ensure proper placement just between the patella and free fragment. Once proper placement was established, we injected 2 mL of 1% lidocaine and 5 mg of triamcinolone acetonide between the patella and free fragment (Fig. 2). We subsequently identified the vastus lateralis tendon and lateral retinaculum contiguous to the accessory fragment, and punctured 10 sites from one

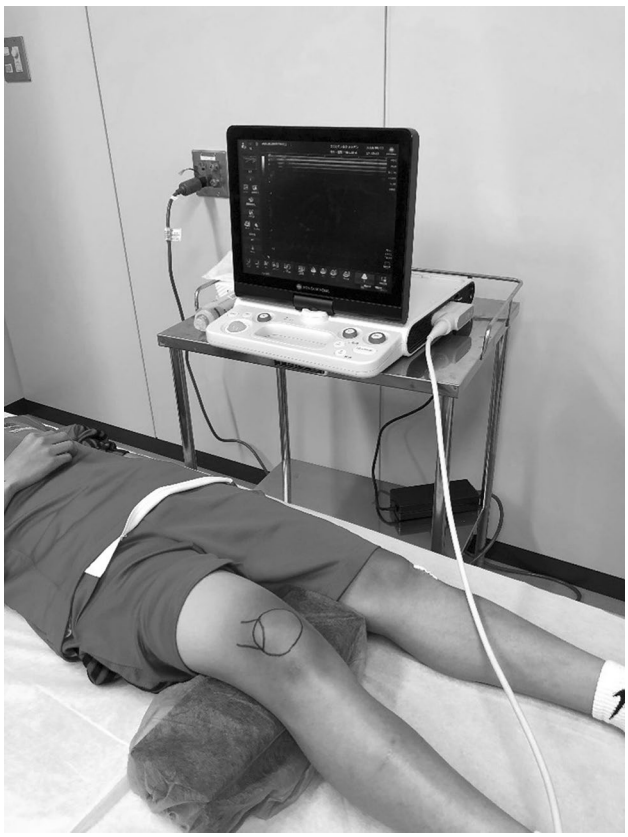
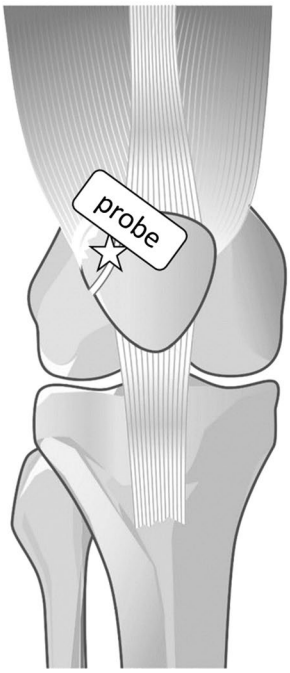
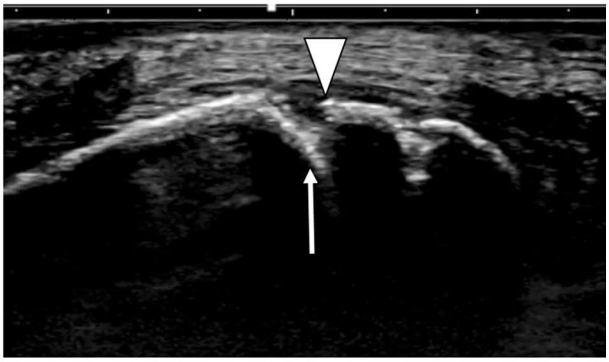


Fig. 1 Patient position during the procedure. A pillow is placed under the patient's knee, which creates a slight flexion of the knee joint. The ultrasound system is placed on the other side of the patient





Arrow: Between patella and free fragment
Arrow head: Needle

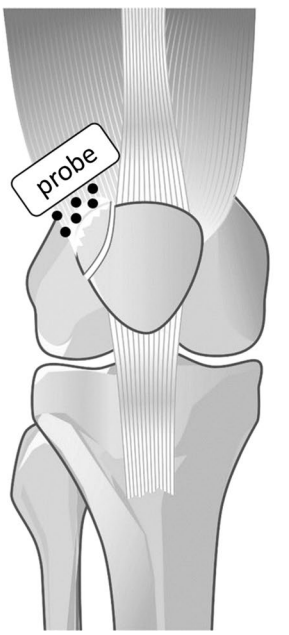
Fig. 2 Ultrasonographic guidance injection. The arrow indicates the area between the patella and free fragment. The arrow head indicates the needle tip. We usually perform this injection using the out-of-plane approach

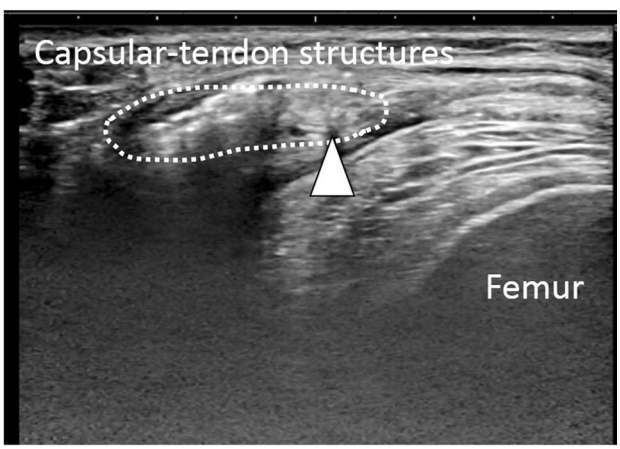
skin puncture with a 38-mm 18-gauge needle to lengthen these structures (Fig. 3).

Post-procedure rehabilitation protocol

To avoid hematoma formation on the first day after the procedure, wounds were pressed with gauze and carefully examined the next day. We also ordered rest for 1 day after the procedure and allowed exercise only after hemostasis was confirmed. Exercise was recommended as follows: flexion and extension exercises 2 days after the procedure, running exercise 4 days after the procedure, and complete return to sports activities at the patient's discretion, but at least 1 week after the procedure. No braces were to be used following this procedure, and full weight-bearing was allowed as tolerated immediately after the procedure.

The ultrasonographic procedure was repeated every 2–4 weeks according to the patient's wishes. If treatment did not improve symptoms, accessory fragment extraction was performed under general anesthesia.





Arrow head: Needle

Fig. 3 Ultrasonographic pie crust technique. The arrow head indicates the needle tip. Dots indicate capsular-tendon structures. We perform the "pie crust" technique using the out-of-plane approach

Statistical analysis

For a statistical power of 80% where $P < 0.05$ is significant, a total of 12 cases were needed to observe a significant difference between pre- and post-procedural VISA scores. Student's *t* test was used to compare VISA scores between each time point, with SPSS (SPSS Inc., Chicago, IL) being used for data analysis. Data are presented as mean ± standard deviation.

Results

The mean duration from symptom onset to the procedure first being performed was 4.5 ± 2.0 months, and the procedure was performed an average of 2.0 ± 1.1 times (Table 1). Mean VISA scores were 45.7 ± 4.7 before treatment, 70.6 ± 10.3 at 1 week after treatment, 84.4 ± 16.6 at 1 month after treatment, and 88.6 ± 18.3 at 3 months after treatment. VISA score improvements from baseline to 1 week after treatment, and from 1 week to 1 month after treatment, were significant (both $P < 0.01$), while the improvement between 1 and 3 months after treatment was not. Two patients (three knees) had poor results and could not return to action, and thus underwent surgical treatment 4 months after the ultrasonographic procedure. However, the other 12 patients were able to fully return to action a mean of 4.2 ± 2.1 weeks after the procedure. There were no complications in any of the patients.

Discussion

The most important finding of this study was that the ultrasound-guided injection and the "pie crust" technique for the lengthening of the vastus lateralis tendon and lateral retinaculum under local anesthesia significantly improved the mean VISA scores post-treatment without procedure-related complications in cases of symptomatic type III bipartite patella.

Although several treatment options have been proposed for bipartite patella, there remains some controversy regarding the best therapeutic option [10]. Generally, most cases of symptomatic bipartite patella are treated conservatively, with surgical management only being considered when conservative treatment fails. This can be more likely in athletes due to their desire to return quickly to sports activities; indeed, the reported success rate of conservative therapy is 38% among athletes [11, 13]. However, some authors have reported positive results for conservative therapy, with symptom resolution and return to action being achieved after 45–90 days [14, 15]. Nevertheless, due to the low reliability of conservative therapy and the long period of time before being able to return to action, athletes often find it difficult to accept it as a treatment option.

Regarding surgical treatment, Matic et al. reported that excision of the accessory fragment is the most successful method in returning athletes to action without symptoms [11]. In their review, they found that 67% of patients undergoing surgery had some form of excision of the fragment, and that this had a 100% success rate at returning patients

Table 1 Overall results for patients treated with the ultrasonographic procedure

Case	Age	Sports	Side	Symptom duration, months	VISA score					
					Pre-procedure	1 week	1 month	3 month	Number of procedures	Outcome
1	13	Soccer	Right	6	50	65	82	100	2	RTP
2	13	Soccer	Left	6	50	48	100	100	2	RTP
3	14	Soccer	Left	4	42	64	76	100	2	RTP
4	14	Soccer	Left	3	45	83	100	100	1	RTP
5	12	Baseball	Left	6	54	66	82	100	2	RTP
6	13	Soccer	Right	4	48	67	48	45	4	Surgery
	13	Soccer	Left	4	45	80	54	51	4	Surgery
7	13	Basketball	Right	2	42	67	81	75	4	Surgery
8	14	Soccer	Left	5	42	64	81	88	2	RTP
9	15	Soccer	Left	6	40	66	100	100	1	RTP
10	16	Soccer	Left	10	49	76	81	85	1	RTP
11	11	Volley ball		3	40	82	100	100	1	RTP
12	14	Soccer	Left	2	45	82	100	100	1	RTP
13	10	Soccer	Right	4	54	85	100	100	1	RTP
14	10	Soccer	Left	3	42	64	81	85	2	RTP
Ave.	13 ± 1.6			4.5 ± 2.1	45.8 ± 4.6	70.6 ± 10.3	84.4 ± 16.6	88.6 ± 18.3	2.0 ± 1.1	

to prior activities. This was achieved without symptoms in 91% of patients, while the remaining 9% returned to action with residual symptoms. Feil et al. also summarized cases of athletes surgically treated for bipartite patella [14]. Several surgical methods were included in their report, with the time taken to return to action ranging from 30 to 150 days after surgery [14]. This is in contrast to our study, which found that patients could resume sports much sooner at 4.5 ± 1.7 weeks after the ultrasonographic procedure.

Our advantageous results were likely due to the non-surgical lengthening of the vastus lateralis tendon and lateral retinaculum. These structures provide significant restraint on the patella, with the pain associated with bipartite patella being theoretically caused by fragment micro-movement or detachment due to traction forces applied during knee extension [6, 8, 9, 16, 17]. Furthermore, the fibrocartilaginous layer between the accessory fragment and patella is brittle, and has been hypothesized to play the main role in the pathogenesis of symptoms [18]. These problems can be countered by lateral soft tissue procedures, which decrease the direct forces of the extensor mechanism on the fragment, thereby decreasing symptoms [8, 9]. Surgical procedures involving the lateral soft tissues without excision of the fragment are therefore effective in restoring normal patellofemoral tracking. For example, Ogata et al. reported a similar procedure to ours, involving subperiosteal detachment of the vastus lateralis muscle's insertion on the fragment [17]. However, because many athletes do not wish to undergo surgical treatment, we believed it necessary to devise an effective conservative therapy. Our procedure was devised by adapting techniques performed during total knee arthroplasty [19] and arthroscopic meniscectomy [20], with a focus on lengthening the vastus lateralis tendon and lateral retinaculum, and decreasing inflammation at the fibrocartilaginous layer between the fragment and patella. A key advantage of our procedure is the use of local injection under ultrasonographic guidance, which enables lidocaine and steroids to be precisely injected between the patella and fragment, as well as non-surgical lengthening of the vastus lateralis tendon and lateral retinaculum.

Despite the insights provided by this study, it does have some limitations. First, the degree of vastus lateralis tendon and lateral retinaculum lengthening using our method of 10 punctures still needs to be investigated. Second, three of the 15 knees in our study required additional surgery. Although this was not a high percentage, this may indicate that our technique still needs improvement. Third, our study did not have a randomized controlled design; therefore, although the results are promising, future prospective randomized controlled studies may be helpful in providing more robust evidence regarding the effectiveness of this technique. Fourth, we need to perform fresh cadaver or animal experiments to understand the mechanism of this procedure in the future. Finally, the need for clinicians to become accustomed to ultrasound, and therefore the performance of our technique being influenced by clinician proficiency, is a major challenge. Nevertheless, the procedure had no complications, could be performed under local anesthesia at an outpatient clinic, and was effective in reducing clinical symptoms. It is thus a promising new treatment option for symptomatic bipartite patella.

Conclusions

The performance of ultrasound-guided injection and the "pie crust" technique for the lengthening of the vastus lateralis tendon and lateral retinaculum under local anesthesia was found to safely and effectively treat symptomatic type III bipartite patella. This was particularly supported by the significant improvement in the mean VISA scores post-treatment, and the absence of procedure-related complications. Thus, we recommend consideration of this novel technique for the treatment of symptomatic bipartite patella prior to surgical treatment in cases where other conservative treatment methods are unsuitable.

Compliance with ethical standards

Conflict of interest The authors have no conflicts of interest to declare.

Ethical statement Ethical approval for the present study was obtained from our institutional review board. Patients were informed of the study aims and procedures, and they provided written informed consent along with their parents.

Informed consent Patients were informed of the study aims, procedures, and publication, and they provided written informed consent along with their parents.

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