Technical Note

Real-Time Virtual Sonography-Guided Ossicle Removal in Unresolved Osgood-Schlatter Disease

Nobutake Ozeki, M.D., Ph.D., Hideyuki Koga, M.D., Ph.D., Tomomasa Nakamura, M.D., Ph.D., Yusuke Nakagawa, M.D., Ph.D., Takashi Hoshino, M.D., Ph.D., Masaki Amemiya, M.D., Ph.D., and Ichiro Sekiya, M.D., Ph.D.

Abstract: Osgood-Schlatter disease (OSD) reduces participation in sports activities for adolescents, and, in unresolved cases of the disease in which daily life or sports activity after skeletal maturity are affected, surgical intervention to remove the ossicle is performed to alleviate symptoms. We present a real-time virtual sonography (RVS)−guided ossicle removal in unresolved OSD. The knee joint angle is set at 20°, which is the same position used in magnetic resonance imaging. A 1.5-cm longitudinal skin incision is made at the medial side of the tuberosity. An ultrasound probe covered with a sterile sleeve is then placed longitudinally at the level of tuberosity. The forceps is inserted to peel the patellar tendon off the posterior side of the ossicle. Then the anterior side of the ossicle is peeled off in both the transverse and longitudinal views. When the ossicle is unstable enough, forceps are used to grasp the ossicle and carefully remove it. RVS can see magnetic resonance imaging information in the surrounding area beyond what can be detected by the ultrasound probe, and RVS enables easy determination of the anatomical position of the ossicle, and removal of the ossicle is achieved with low invasiveness.

Osgood-Schlatter disease (OSD), an apophysitis of the tibial tuberosity and a common cause of anterior knee pain during childhood growth, reduces participation in sports activities for affected patients.[1] Repeated traction forces from the quadriceps to the ossification centers cause avulsion of segments of tibial tuberosity. Symptoms usually improve with suspension of sports activities, and the prognosis is good in most cases. However, some patients have persistent pain, even after the closure of the growth plate, despite conservative treatment. In unresolved cases of the disease in which daily life or sports activity after skeletal maturity is affected, surgical intervention to remove the ossicle is performed to alleviate symptoms.[2]

Arthroscopic removal of the ossicle reportedly minimizes the invasion.[3-5] Compared to open surgery, arthroscopic excision is more beneficial because the patellar tendon is not injured, and only 2 small skin incisions are required. However, arthroscopic surgery alone requires intraoperative fluoroscopy to confirm the location of the ossicle, which is covered by the bursa. Hence, reports mention the combined use of ultrasound for arthroscopic guidance,[4,5] but with the disadvantage of a small working portal of the arthroscope, especially when a nano-arthroscope is used.

The real-time virtual sonography (RVS) system uses a magnetic position tracking system to coordinate ultrasonography (US) and magnetic resonance imaging (MRI) images, and both US and MRI images of the same site are simultaneously displayed on 1 monitor in real time. RVS has been clinically used in the biopsy of breast or prostate cancers,[6-8] identification of inflammatory diseases,[9] and diagnosis of anterolateral ligament injury.[10] With the increase in ultrasound-assisted procedures in orthopaedic surgery,[11-13] computed tomography (CT)−ultrasound fusion-guided hip endoscopy has been reported for the successful removal of an impinging poly L-lactic acid screw.[14]

From the Center for Stem Cell and Regenerative Medicine Tokyo Medical and Dental University Hospital of Medicine, Tokyo, Japan (N.O., I.S.); the Department of Joint Surgery and Sports Medicine, Graduate School of Medical and Dental Sciences Tokyo Medical and Dental University Hospital of Medicine, Tokyo, Japan (H.K., T.N., Y.N.); and the Clinical Center for Sports Medicine and Sports Dentistry Tokyo Medical and Dental University Hospital of Medicine, Tokyo, Japan (T.H., M.A.).

Received September 8, 2023; accepted November 27, 2023.

Address correspondence to Nobutake Ozeki, M.D., Ph.D., Center for Stem Cell and Regenerative Medicine, Tokyo Medical and Dental University, 1-5-45 Yushima, Bunkyo-ku, Tokyo 113-8519, Japan. E-mail: ozeki.arm@tmd.ac.jp

2212-6287/231287
https://doi.org/10.1016/j.eats.2023.102897

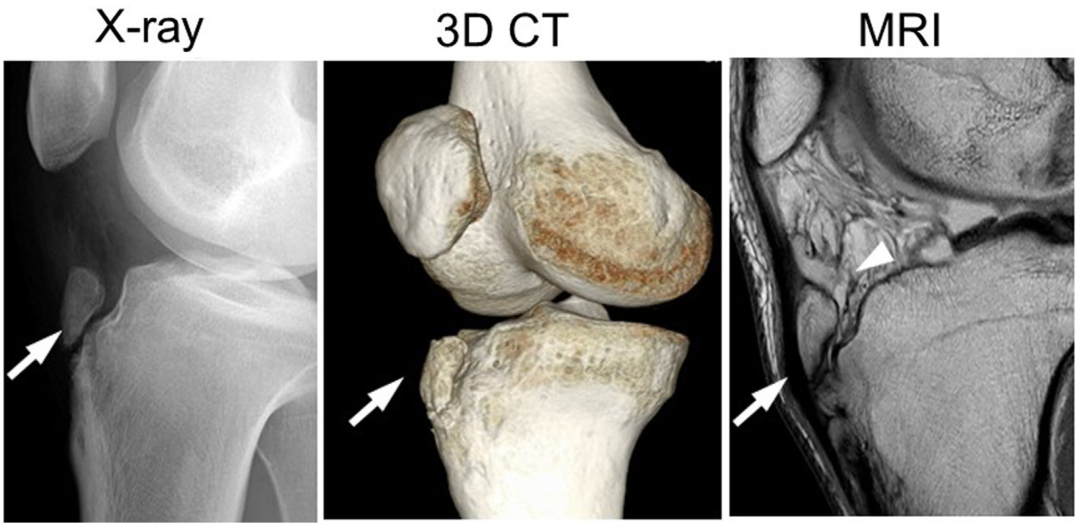

Fig 1. Preoperative images of the ossicle in the right knee joint. The ossicle is observed in plain X-ray film, 3-dimensional computed tomography, and magnetic resonance imaging (MRI) (arrow). Inflammation of the deep infrapatellar bursa is indicated by the arrowhead in the MRI scan.

Here, we present an ultrasound-fusion technique for removal of the ossicle in patients with Osgood-Schlatter disease.

Indications, Preoperative Patient Evaluation, and Imaging

This technique is indicated for patients with anterior knee pain due to an ossicle resulting from unresolved Osgood-Schlatter disease. In preoperative physical examination, tenderness at the tuberosity is usually observed. The ossicle is identified by preoperative plain radiography, CT, and MRI (Fig 1). MRI also shows the inflammation of deep infrapatellar bursa. Based on the physical examination and clinical images, a surgical indication for removal of ossicle has been determined.

Preparation of Real-Time Virtual Sonography

MRI is performed using a 3.0T scanner (Achieva 3.0TX; Philips, Amsterdam, Netherlands) with 16-channel coils. Digital imaging and communications in medicine data of a proton-weighted image of the sagittal and axial plane, with a thickness of 0.36 mm, is transferred to an RVS system (ARIETTA 850 DeepInsight; Fujifilm Healthcare Corporation, Tokyo, Japan). RVS consists of an ultrasound probe, magnetic sensor, magnetic field generator (transmitter), and workstation built into the ultrasound machine (Fig 2). An ultrasound probe has a 5 to 18 MHz transducer, and the magnetic sensor is attached to the probe. The sensor senses the magnetic field and detects the position and motion of the probe during scanning using a magnetic position tracking system. The scan angle and position of information of the probe are transmitted to the workstation. The workstation computes the positional information to display an MRI-multi-planar reconstruction image corresponding to the ultrasound image in real time. For correct geographical synchronization of the 2 different modalities with the magnetic navigation system, reference point for the first registration is performed using the center of the patella, which is easily identified in both modalities.

Surgical Technique

The patient is placed in the supine position on a standard operating table (Video 1). The knee joint angle

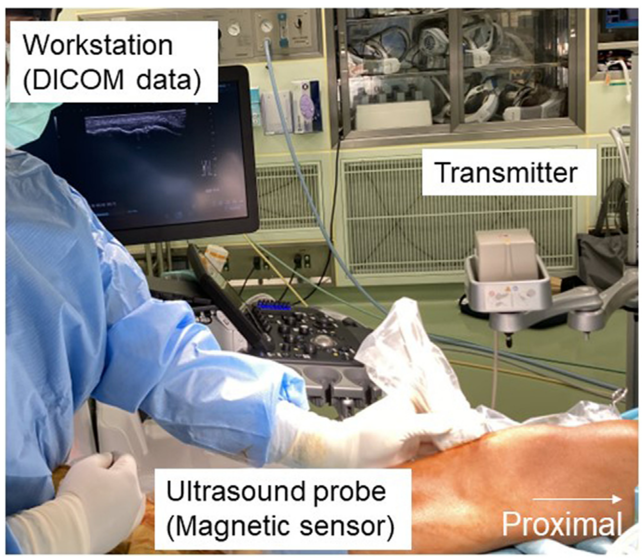

Fig 2. Settings of real-time virtual sonography for the right knee joint. Real-time virtual sonography consists of an ultrasound probe, magnetic sensor, magnetic field generator (transmitter), and workstation.

is set at 20°, which is the same position used in MRI scanning. A 1.5-cm longitudinal skin incision is then made at the medial side of the tuberosity. An ultrasound probe covered with a sterile sleeve is then placed longitudinally at the level of tuberosity. From the skin incision, the forceps is inserted to peel the patellar tendon off the posterior side of the ossicle (Fig 3A). Then the ultrasound probe is set transversely to confirm the location of the forceps in the short axis (Fig 3B), followed by peeling. In the same way, the posterior side of the ossicle is peeled off in both the transverse and longitudinal views. When the ossicle is unstable enough (Fig 3C), forceps are used to grasp the ossicle and carefully remove it. An example of the removed ossicle and the skin incision is shown in Figure 4B. Pearls and pitfalls of this technique are described in Table 1.

Postoperative Course

Full weightbearing and range-of-motion exercises are allowed from the first postoperative day. The ossicle completely disappears, as shown in the plain radiograph and CT scan, and inflammation of the deep infrapatellar bursa also disappears 3 months after surgery, as shown in the MRI scan (Fig 5). A gradual return to sports is allowed, depending on pain and the recovery of muscle strength.

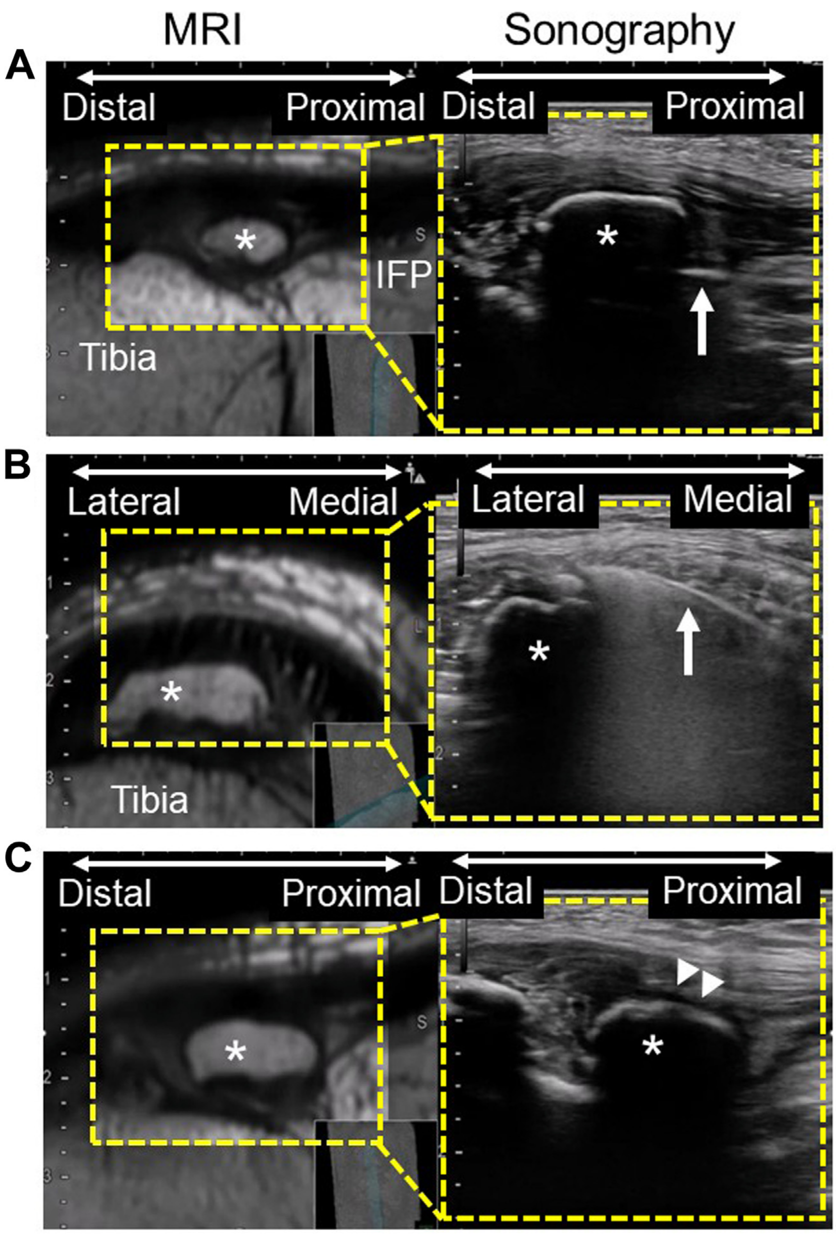

Fig 3. Real-time virtual sonography-guided ossicle resection of the right knee joint. (A) Longitudinal plane. The tip of the forceps (indicated by the arrow) peeling the patellar tendon off the posterior side of the ossicle (*). (B) Horizontal plane. The tip of the forceps (indicated by the arrow) peeling the patellar tendon off the anterior side of the ossicle (*). (C) Longitudinal plane after peeling off the ossicle (*). The space (indicated by arrowheads) can be seen at the anterior side of the ossicle. IFP, infrapatellar fat pad.

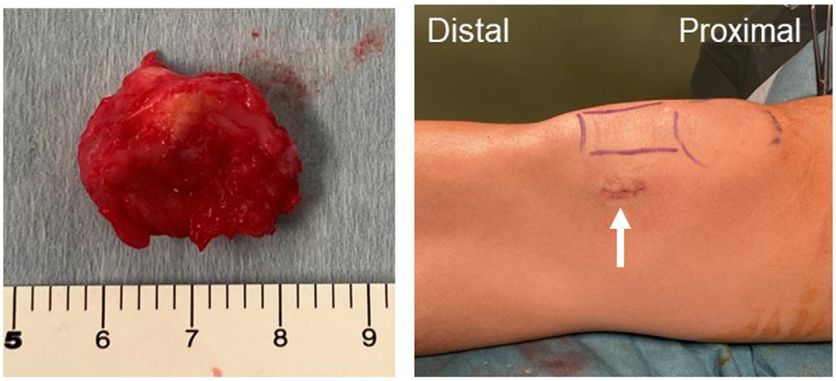

Fig 4. Removed ossicle and skin incision of the right knee joint. The ossicle with a relatively large diameter of 2.6 cm is shown with the measure (left), and the skin incision at the medial side of the tuberosity is indicated by an arrow (right).

Table 1. Pearls and Pitfalls of the Ultrasound-Fusion Technique

Pearls
To synchronize the image of MRI and ultrasound, MRI should be taken at the same position of the surgical intervention.
The patella is used as a reference point for the first registration. The patella is very shallow under the skin, so as the geographical landmark it is optimal.
It is important to check the longitudinal and horizontal axes to ensure that synchronization is completed, and if the synchronization is insufficient, adjust the reference point again to complete image synchronization.
Pitfalls
If the transmitter is far from the probe, the image cannot be detected accurately.
If there is a magnetic material between the probe and the magnetic transmitter, the transmission of information from the probe will be hindered.
The transmitter and probe must be placed within 20 cm to 76 cm of each other, and there must be no obstacles between them, including the surgical assistant.

MRI, magnetic resonance imaging.

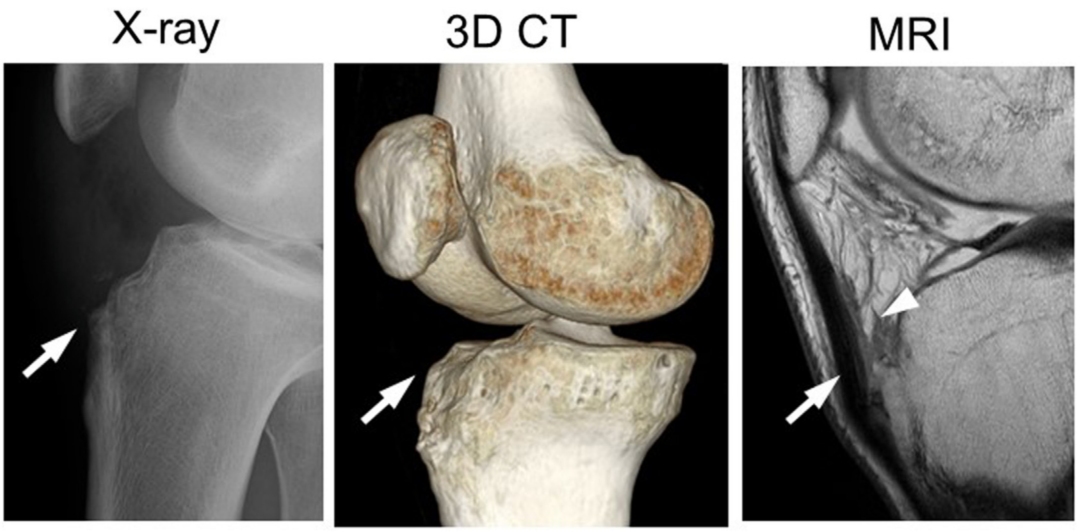

Fig 5. Postoperative images of the right knee joint. Where the ossicle was removed from is indicated by arrows. Inflammation of the deep infrapatellar bursa (indicated by the arrowhead), which was observed before the removal of the ossicle, had disappeared, as shown in the magnetic resonance imaging scan.

Discussion

Here we have introduced RVS-guided ossicle removal in unresolved Osgood-Schlatter disease. Ultrasound scanning is useful to detect the ossicle, but it can only detect the image within the range of the probe. RVS can see MRI information in the surrounding area beyond what can be detected by the ultrasound probe. Moreover, RVS enables easy determination of the anatomical

Table 2. Advantages and Limitations of the Ultrasound-Fusion Technique

Advantages
RVS can see MRI information in the surrounding area beyond what can be detected by ultrasound probe.
RVS enables the anatomical position of the ossicle to be determined easily, and removal of ossicle in unresolved Osgood−Schlatter disease is achieved with low invasiveness.
Limitations
This device uses a magnetic position tracking system for the synchronization of MRI and ultrasound image. Therefore, using this system in patients with a cardiac pacemaker is contraindicated, even when this synchronization is performed on CT and ultrasound.
There is a steep learning curve in handling ultrasound to detect the objects, but this can be resolved with increased clinical use and experience of ultrasound.

CT, computed tomography; MRI, magnetic resonance imaging; RVS, real-time virtual sonography.

position of the ossicle, and removal of ossicle is achieved with low invasiveness.

The most critical point of the current procedure is to synchronize the MRI and ultrasound images. At first, MRI should be taken at the same position of the surgical intervention. Second, the patella is used as a reference point for co-registration. The patella is very shallow under the skin, so as the geographical landmark it is optimal. When the center of the patella is registered, the deep axis is automatically determined. It is important to check the longitudinal and horizontal axes to ensure that synchronization is completed, and, if the synchronization is insufficient, the reference point is registered again to complete image synchronization (Table 1).

This procedure has some pitfalls. If the transmitter is far from the probe, the image cannot be detected accurately. In addition, if there is an obstacle between the probe and the magnetic transmitter, the transmission of information from the probe is hindered. Therefore the transmitter and probe must be placed within 2 m of each other, and there must be no obstacles between them, including the surgical assistant (Table 1).

A critical advantage of this surgical technique is that RVS can see MRI information in the surrounding area beyond what can be detected by the ultrasound probe. Moreover, RVS can determine the anatomical position of the ossicle easily, and removal of ossicle in unresolved Osgood-Schlatter disease is achieved with low invasiveness (Table 2).

This procedure has some limitations. This device uses a magnetic position tracking system for the synchronization of MRI and ultrasound image. Therefore it is contraindicated to use this system in patients with a cardiac pacemaker, even if this synchronization is performed with CT and US. There is a steep learning curve in using US to detect objects, but this can be resolved with increasing clinical use and experience with US (Table 2).

Disclosures

The authors report the following potential conflicts of interest or sources of funding: FUJIFILM lent us the RVS system. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Acknowledgments

We thank Mai Katakura and Aritoshi Yoshihara for expert help with clinical services, as well as Hisako Katano, Mitsuru Mizuno, Kentaro Endo for the management of our departments.

References

1. de Lucena GL, dos Santos Gomes C, Guerra RO. Prevalence and associated factors of Osgood-Schlatter syndrome in a population-based sample of Brazilian adolescents. *Am J Sports Med* 2011;39:415-420.
2. Circi E, Atalay Y, Beyzadeoglu T. Treatment of Osgood-Schlatter disease: Review of the literature. *Musculoskelet Surg* 2017;101:195-200.
3. DeBerardino TM, Branstetter JG, Owens BD. Arthroscopic treatment of unresolved Osgood-Schlatter lesions. *Arthroscopy* 2007;23:1127 e1121-1123.
4. Kamiya T, Teramoto A, Mori Y, Kitamura C, Watanabe K, Yamashita T. Nano-arthroscopic ultrasound-guided excision of unresolved Osgood-Schlatter disease. *Arthrosc Tech* 2021;10:e1581-e1587.
5. Fujita K, Nakase J, Yoshimizu R, Kimura M, Kanayama T, Tsuchiya H. Bursoscopic ultrasound-guided ossicle resection for Osgood-Schlatter disease. *Arthrosc Tech* 2022;11:e841-e846.
6. Nakano S, Kousaka J, Fujii K, et al. Impact of real-time virtual sonography, a coordinated sonography and MRI system that uses an image fusion technique, on the sonographic evaluation of MRI-detected lesions of the breast in second-look sonography. *Breast Cancer Res Treat* 2012;134:1179-1188.
7. Uematsu T, Takahashi K, Nishimura S, et al. Real-time virtual sonography examination and biopsy for suspicious breast lesions identified on MRI alone. *Eur Radiol* 2016;26:1064-1072.
8. Miyagawa T, Ishikawa S, Kimura T, et al. Real-time virtual sonography for navigation during targeted prostate biopsy using magnetic resonance imaging data. *Int J Urol* 2010;17:855-860.
9. Kawai S, Iijima H, Shinzaki S, et al. Usefulness of intestinal real-time virtual sonography in patients with

inflammatory bowel disease. *J Gastroenterol Hepatol* 2019;34:1743-1750.

10. Oshima T, Nakase J, Numata H, Takata Y, Tsuchiya H. Ultrasonography imaging of the anterolateral ligament using real-time virtual sonography. *Knee* 2016;23:198-202.
11. Hattori S, Onishi K, Yano Y, et al. Sonographically guided anchor placement in anterior talofibular ligament repair is anatomic and accurate. *Orthop J Sports Med* 2020;8: 2325967120967322.
12. Ozeki N, Nakagawa Y, Mizuno M, et al. Ultrasound-guided harvesting of synovium for regenerative medicine of cartilage and meniscus using synovial mesenchymal stem cells. *Arthrosc Tech* 2021;10:e1723-e1727.
13. Ozeki N, Koga H, Nakamura T, et al. Ultrasound-assisted arthroscopic all-inside repair technique for posterior lateral meniscus tear. *Arthrosc Tech* 2022;11: e929-e935.
14. Miyatake K, Choe H, Takahiro F, Kawabata Y, Kusaba Y, Inaba Y. Application of Intraoperative CT-ultrasound fusion imaging in hip endoscopy for treatment of iatrogenic impingement due to PLLA screw: A novel surgical technique. *Arthrosc Tech* 2023;12:e801-e805.