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IMAGING

Conservative Management and Serial Magnetic Resonance Imaging in an Athlete with Radiographically Unstable Juvenile Osteochondritis Dissecans of the Knee: Case Report

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Abstract

This report describes a case of radiographically unstable knee juvenile osteochondritis dissecans (JOCD) that healed without surgery. The authors utilize objective measurements of serial magnetic resonance imaging (MRI) to evaluate healing of the JOCD lesion and inform the decision to continue the course of conservative care or proceed to surgery. A 15-year-old soccer player presented with a 1-month history of worsening left knee pain. Magnetic resonance imaging showed an osteochondral lesion of the lateral femoral condyle with highly specific signs of instability including multiple cyst-like lesions (CLL) and large CLL diameter. An approach involving low-impact, low-intensity rehabilitative exercises and other modalities was implemented. Follow-up MRIs were performed at 3, 6, and 8 months to monitor changes and recalculate healing probability using a previously published nomogram. Clinical improvement was measured using outcome assessments. Follow-up MRIs showed a progressive reduction in size and number of CLLs and a resulting increase in healing probability from 20 to 70%. The patient successfully returned to play at just over 8 months after diagnosis. This case highlights that significant healing in knee JOCD is possible during a carefully monitored course of non-operative care, despite imaging signs of instability such as multiple and large CLL.

Keywords Osteochondritis dissecans · Osteochondral · Rehabilitation · Exercise · Laser therapy · Nomogram · Nutraceutical

Background

Osteochondritis dissecans is an injury of subchondral bone involving fracture and ischemia [1]. This disorder has biological risk factors such as genetics, ossification center defects, and endocrine abnormalities (e.g., vitamin D deficiency) [1]. Mechanical risk factors include repetitive microtrauma, tibial spine impingement, and altered biomechanics [1]. This lesion is classified as the juvenile form of osteochondritis dissecans when it presents in a femur with open distal physes [2]. Knee juvenile osteochondritis dissecans (JOCD) is most common between the ages of 11 and 15 [3] with an incidence during this age of 39 per 100,000 for males and 16 per 100,000 for females [3].

The management of knee JOCD depends, in part, on it being stable or unstable [2, 4]. Patients with unstable lesions have a worse prognosis with non-operative treatment and are more likely to undergo surgery [5, 6]. Signs of instability include a line of high signal intensity between the lesion and adjacent bone on T2-weighted MRI, a focal osteochondral defect, an articular fracture in the subchondral bone plate [6], and the presence of multiple CLL or a large CLL > 5 mm in diameter, which have a high specificity (~100%) for instability [7].

The healing probability of knee JOCD is individualized as it depends on clinical and radiological variables. Estimates of what percentage of cases heal vary from 30 to 95% over 6–48 months [5, 6, 8–14]. Variables associated with a greater probability of healing include a smaller lesion size [6, 11, 12, 14], age < 16 [6, 10, 11], absence of mechanical symptoms

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(e.g., giving-way, swelling, locking, or clicking) [12], median CLL size < 1.3 mm on MRI [11], and time to consultation < 6 months [13].

Two published nomograms can be used to predict healing of knee JOCD. Both use clinical and radiological variables to estimate the probability of imaging signs of healing at 6 months. Krause et al.'s nomogram uses age, normalized lesion width, and median CLL size, which has the greatest validity of any marker predicting healing of knee JOCD [11]. Wall's nomogram uses normalized lesion width (Fig. 1), length, and symptom type [12].

This case illustrates that a non-operative approach for knee JOCD in an athlete can be supported by serial improvements on MRI. Currently, there is no standard rehabilitation protocol for JOCD [2], and activity restriction prior to follow-up imaging is common [6, 11–13]. In this case, innovative rehabilitation and treatment strategies enabled a return to play despite a low initial healing probability.

Case Presentation

A 15-year-old soccer player presented with a 1-month history of gradually worsening left knee pain, aggravated by a recent knee-to-knee collision. He had prior episodes of mild bilateral anterior knee pain during soccer, diagnosed as patellar tendinitis. There was no family history of JOCD. Examination of the left knee revealed infrapatellar swelling and tenderness, pain with inferior patellar glide, and passive knee range of motion, but retained ability to achieve full range of motion. Knee radiography showed a subchondral lucency in the left lateral femoral condyle, and an MRI confirmed the presence of a JOCD lesion in that region. The lesion had five CLL, the largest of which was 5.9 mm in diameter. The patient's orthopedist referred him for conservative therapy with the intention of having a follow-up MRI in 3 months.

Two weeks after the left knee JOCD diagnosis, blood flow restriction training (BFRT) was initiated twice per week and was continued until 31 weeks. An 11.5-cm-wide pneumatic cuff device (Delfi Medical Innovations) was applied to the patient's proximal left thigh, which automatically calculated the limb occlusion pressure (LOP). Pressures from 128 to 179 mmHg, which equaled 80% of the LOP, were used while the patient exercised. The patient rode an exercise bike for 10 min then performed five exercises that varied depending on the day for another 10 min. Initially, these consisted of non-weight-bearing, low-intensity exercises such as clam shells and active straight leg raises. Between appointments, the patient performed BFRT at home for two 10-min sessions on a stationary bicycle with a 7.5-cm-wide elastic wrap around the proximal thigh (BFR Bands®) each day.

Three weeks after the left knee JOCD diagnosis, near-infrared light and nutritional therapies were initiated. A Class IV laser (Diowave™) was applied to the left knee at 45 W for 100 s, twice per week. Between appointments, the patient used a near-infrared bulb (RubyLux NIR-A Therabulb) for 30 min, 6″ from the knee at home daily. The patient complied with advice to take orally 2000 IU vitamin D_3 and 100 micrograms vitamin K_2 daily.

Seven weeks after the left knee JOCD diagnosis, the patient's reduction in pain to a mild level and absence of swelling supported a progression to low-impact weight-bearing exercises including step-downs, step-ups, monster walks, and body weight split squats. At 12 weeks, the normalization of outcome assessments supported a progression to sled pushes and pulls.

During the 14th week after left knee JOCD diagnosis, the patient noted a gradual re-aggravation of right anterior knee pain during exercises, of which he had similar episodes 1 year prior. Examination revealed tenderness of the tibial tuberosity. Radiography demonstrated an ossicle at the distal patellar tendon consistent with Osgood-Schlatter disease and a subchondral plate irregularity at the lateral femoral trochlea. Magnetic resonance imaging showed a small stable osteochondral lesion 9 mm in diameter without CLL. Because the patient was restricted from sports due to his left knee JOCD, he elected to have the ossicle related to his Osgood-Schlatter removed from the right knee. Surgery was completed 16 weeks after his left knee JOCD diagnosis. Right knee symptoms related to post-surgical healing subsided over another 16 weeks.

From 16 to 20 weeks after the left knee JOCD diagnosis, exercises regressed to non-weight-bearing due to demands of post-surgical recovery of the right knee. At week 20, step-ups, step-downs, and monster walks were re-introduced. At week 22, pulsed electromagnetic field (PEMF) therapy (Pulse XL Pro™) was applied to both knees for 30 min at 7.8 Hz, once per week for 6 weeks. Following a reduction in post-surgical pain and swelling, the patient was progressed at week 23 to walking lunges and running on an anti-gravity treadmill (AlterG®) at 60% bodyweight.

Discussion

The patient showed clinical and symptomatic improvement within the first 6 weeks of treatment. His Activity Measure for Post-Acute Care improved from an initial 36 to a maximum of 39 at 11 weeks after left knee JOCD diagnosis and his left Knee Outcome Survey (KOS) increased from an initial 46 to 100% at 12 weeks (Fig. 2). He progressed through rehabilitation without re-aggravating the left knee.

Clinical, symptomatic, and radiological signs of improvement supported a gradual return to playing soccer. At 28 weeks after the left knee JOCD diagnosis, the patient began light passing and kicking of the soccer ball and running 2 miles

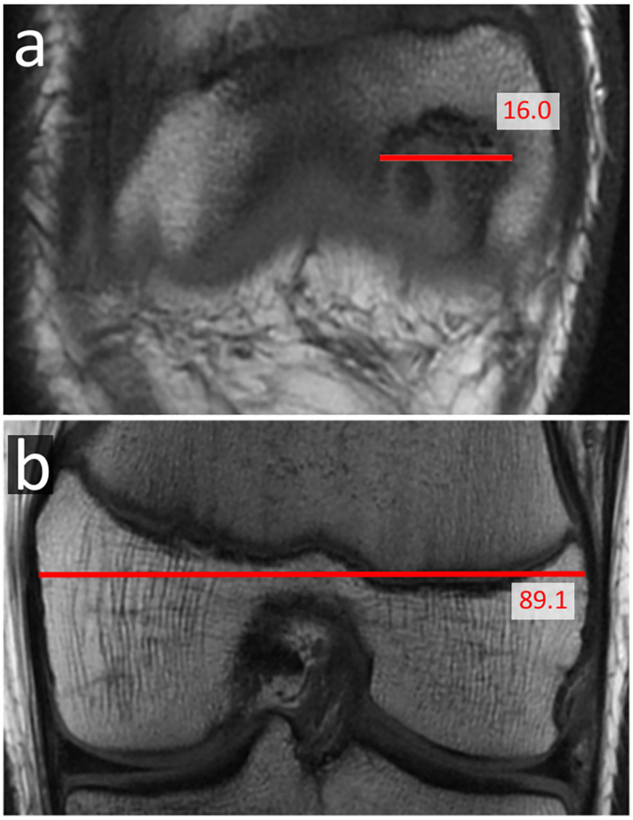


Fig. 1 Normalized lesion width calculation. **a** The maximal medial to lateral dimension in millimeters of the OCD lesion on a coronal MRI was divided by **b** the maximal medial to the lateral dimension of the femoral condyles on a coronal MRI according to the method of Krause et al. [11], which gave a value of 18%

twice per week at 70% body weight on the AlterG®. He was cleared for soccer drills with a trainer at 30 weeks. The patient was fully cleared for soccer matches at 36 weeks. At 4-month follow-up the patient did not have a recurrence of knee symptoms. The patient's outcome and short healing time frame were considered optimal given the low initial probability of healing (20%).

Serial MRI showed progressive healing throughout treatment (Fig. 3). The number and size of CLL reduced from 5, with a median diameter of 3.7 mm at the initial MRI, to 2 with a median diameter of 3.1 mm at the 3-month MRI. At the 6-month MRI, the lesion had one 1.8-mm CLL. The final MRI at 8 months revealed no CLL.

In our case, a short follow-up MRI at 3 months helped determine if the knee JOCD lesion was worsening or healing. The presence of multiple CLL with a maximum diameter > 5 mm indicated instability was likely. No change or worsening of imaging findings such as increased lesion size or CLL size or number would have been indications for surgery while improvement supported ongoing conservative treatment. There is no nomogram score that absolutely indicates surgery however a score of < 48% has a positive predictive value of 65% for predicting the need for surgery [11].

We used Krause et al.'s nomogram to predict healing probability because it accounted for signs of instability such as multiple and large CLL (Fig. 4). Cyst-like lesion size has the best validity of any healing marker for knee JOCD [11] (Fig. 5). According to Krause et al.'s nomogram, the probability of our patient's JOCD healing increased from a baseline of 20 to 26%, 40%, and 70% at the 3, 6, and 8-month follow-up MRIs, respectively. We did not track the coalescence of bone, which is not easily measured, or changes on radiography, which lack standardization [16].

Previous authors have defined healing of JOCD using clinical and/or radiological features. Clinical signs include an absence of pain or functional limitations [6] and the ability to return to sport without recurrence of symptoms [14]. Radiographic signs include a resolution of the boundary between the JOCD lesion and parent bone and increasing radiodensity of the lesion [17]. Magnetic resonance imaging signs include coalescence [8], also called consolidation [10] or fusion [9] of viable bone, return of articular cartilage to normal width and intensity [8], increased T2 signal of the JOCD lesion from low to intermediate [9], obscuring of the lesion-bone interface [9], and reduction of lesion size by 15% [11].

Aside from restriction of strenuous physical activity [2], there is no standardized protocol for conservative management of JOCD of the knee in the published literature [2].

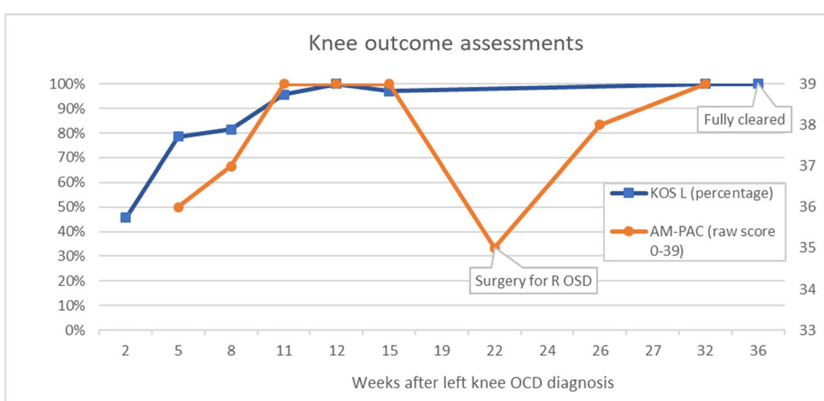


Fig. 2 Knee Outcome Survey (KOS) and Activity Measure for Post-Acute Care (AM-PAC) scores during treatment. At 22 weeks, the patient's AM-PAC score dropped due to having surgery for the R knee Osgood-Schlatter lesion (OSD)

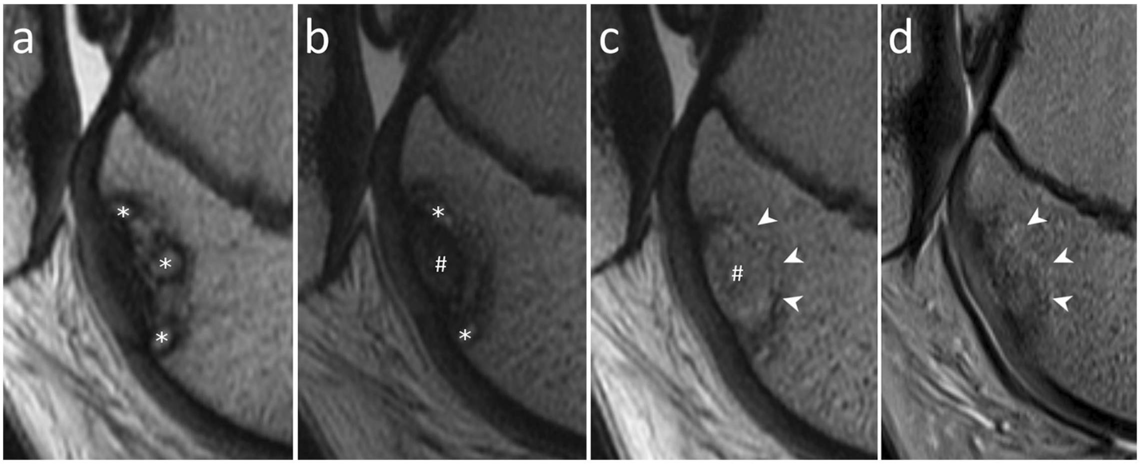


Fig. 3 Signs of healing of the left knee JOCD lesion on serial MRI. **a** Initial MRI, **b** 3-month, **c** 6-month, and **d** 8-month follow-up MRIs. Cyst-like lesion (*) number and size reduced the most from **a** to **b**, filling in of the bony defect (#) was most apparent between **b** and **c**, and obscuring of the lesion-parent bone interface (arrowheads) was most apparent from **c** to **d**

Evidence suggests repetitive stress with activities like running and jumping should be avoided but quadriceps strengthening is beneficial [2]. Patients may continue to perform their daily activities however total rest and immobilization are unnecessary [2]. In our case, we followed these general guidelines with emphasis placed on quadriceps strengthening.

Blood flow restriction training is a method of exercising with a cuff or wrap around a proximal extremity which restricts venous return. This technique allows for rehabilitation using low loads by making exercise more metabolically demanding. It may even increase bone turnover and benefit bone health [18]. Evidence is limited to one case that showed improvements in an adult OCD lesion on radiography after 6 weeks of BFRT [19].

We recommended vitamins D_3 and K_2 to aid in bone ossification. Although no studies have examined the treatment of JOCD using D3 and K2, this combination has been found to safely increase bone density in postmenopausal women [20]. One study that identified vitamin D deficiency in a majority of JOCD patients suggested early D_3 supplementation could prevent the worsening of an OCD lesion [21]. Because we were unable to obtain a baseline serum level of 25-hydroxy vitamin D, we used a dose considered to be safe.

Near-infrared light therapy was used to accelerate the healing of the left knee JOCD using a laser in the clinic and bulb for home use. Near-infrared light may accelerate the healing of bone injuries by stimulating osteoblasts [22]. Evidence is limited to animal studies, such as one animal study that found laser therapy improved signs of healing of osteochondral defects [23].

Pulsed electromagnetic field therapy was used to accelerate the healing of the left knee JOCD and post-surgical recovery of the right knee. Animal studies have shown that PEMF therapy increases mineralization and bone callus density following injury [24]. Evidence in humans is limited to one trial that found PEMF reduced pain and improved function of patients who had surgery for ankle osteochondral lesions [25].

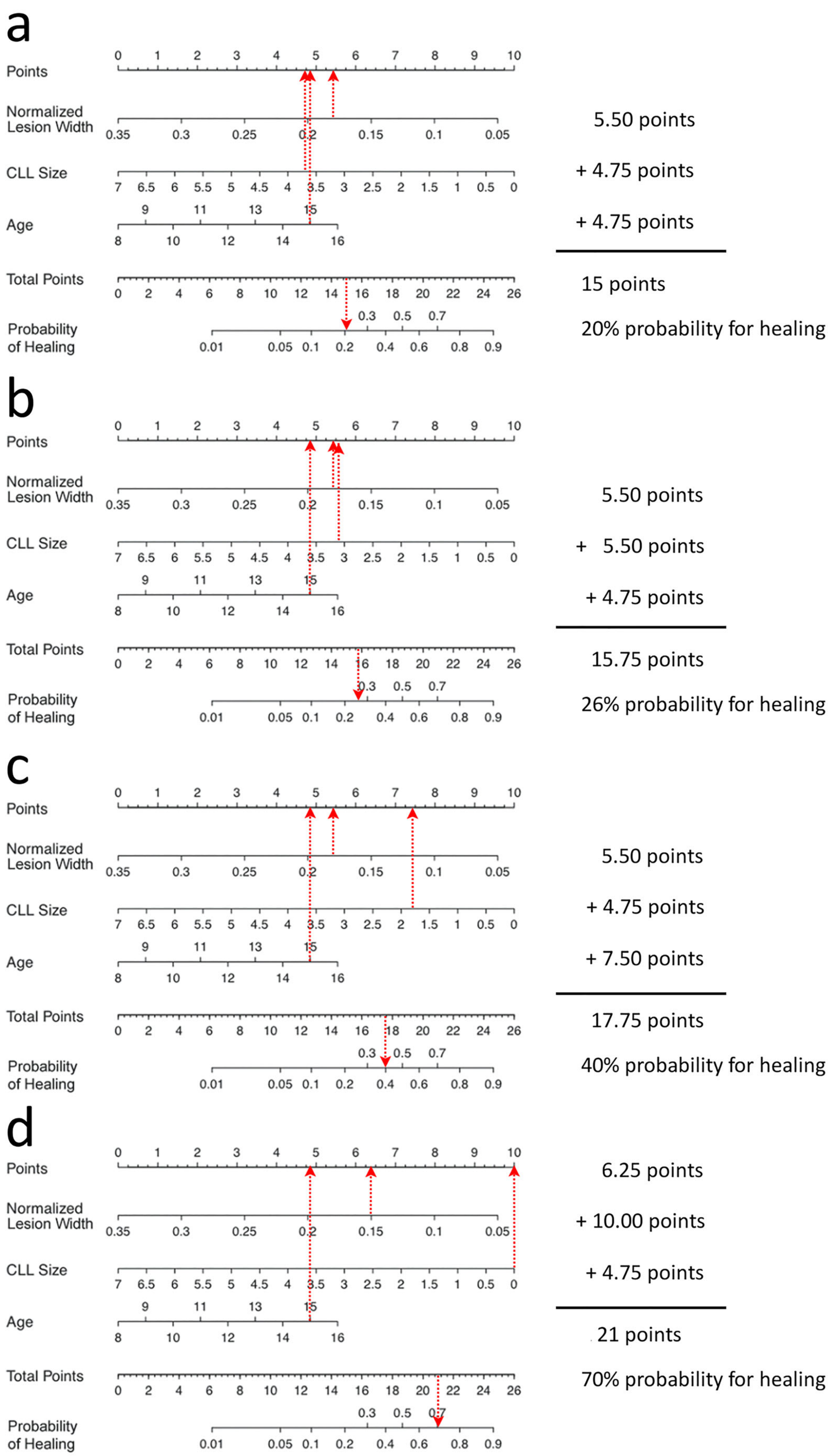
Another treatment option for knee OCD is surgery. The most common indication for surgery is a failure of 6 months of non-operative treatment [4]. Other indications include a lack of radiographic improvement and lesion instability [4]. The surgical techniques most frequently used for knee JOCD are transarticular drilling for stable JOCD and bioabsorbable pin fixation for unstable JOCD [26].

One review found that surgery had a success rate of over 90% after 38 to 95 months [4]. However, there is a lack of data regarding post-surgical outcomes of pediatric patients once they reach skeletal maturity years later [4, 26]. Complications of surgical intervention include post-operative pain during sport [26] and damage to articular cartilage [4].

Other therapies are emerging for knee JOCD but are limited to case reports. These include stem cell injections [27], platelet-rich plasma injections [28], and extracorporeal shock wave therapy [2]. Future research should continue to evaluate if changes in short-term follow-up MRI and the corresponding nomogram score help decision-making for knee JOCD. Cohort studies or clinical trials could also examine if BFRT, near-infrared light, vitamins D_3 and K_2, and PEMF accelerate healing of JOCD in comparison with activity restriction alone.

One limitation in this case is any confounding effect of a 4-week period of activity restriction in the middle of the course of care, due to an unrelated contralateral knee

Fig. 4 Improvements in healing probability from the **a** initial MRI to follow-up MRI at **b** 3 months, **c** 6 months, and **d** 8 months as predicted by the Krause et al.'s nomogram [11]. The normalized lesion width remains a constant 18% in nomogram **a**, **b**, and **c**, and decreases to 15% in nomogram **d**. The median CLL size reduces from **a** 3.7 to **b** 3.1, to **c** 1.8, to **d** 0. Reprinted with permission from Krause et al. viaRightsLink—the order license number is 4746220915007


a
Points
Normalized Lesion Width
CLL Size
Age
Total Points
Probability of Healing
5.50 points
+ 4.75 points
+ 4.75 points
15 points
20% probability for healing
b
5.50 points
+ 5.50 points
+ 4.75 points
15.75 points
26% probability for healing
c
5.50 points
+ 4.75 points
+ 7.50 points
17.75 points
40% probability for healing
d
6.25 points
+ 10.00 points
+ 4.75 points
21 points
70% probability for healing

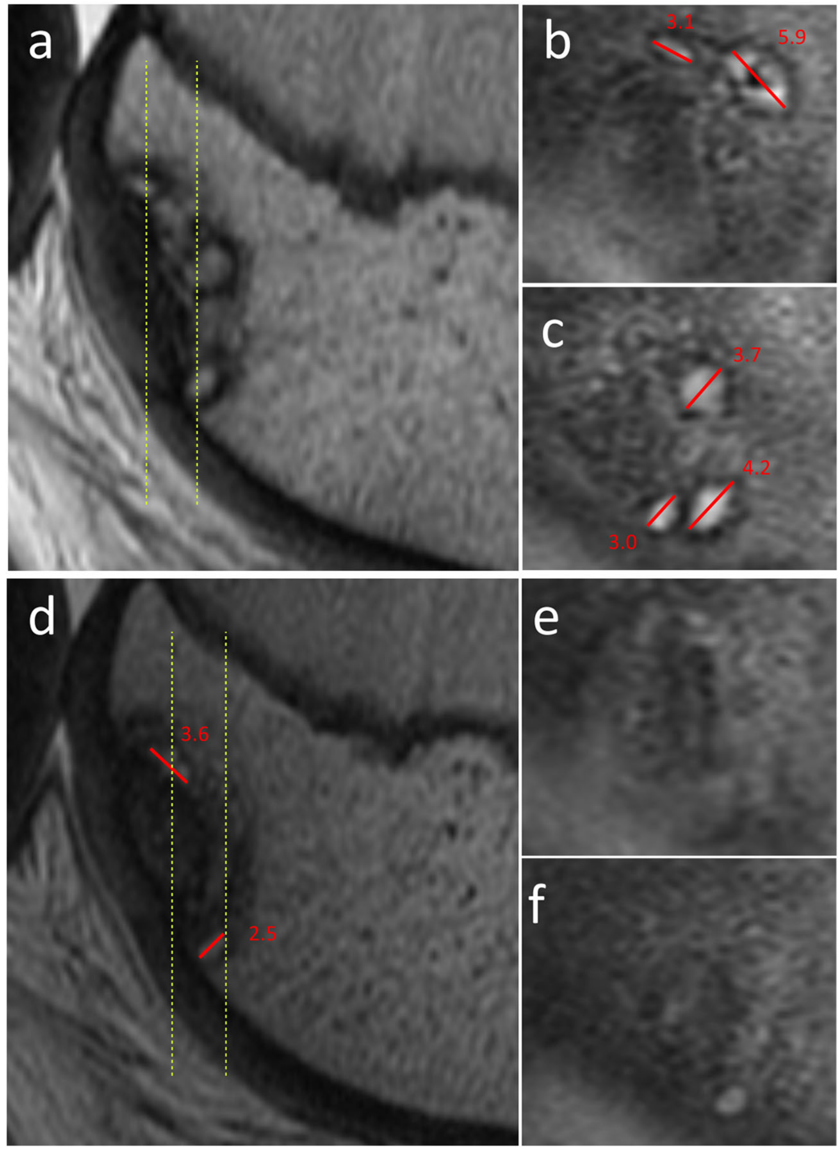


Fig. 5 Reduction in cyst-like lesion size (the most valid measure of healing) and amount from the initial MRI (**a**, **b**, **c**) to the 3-month follow-up MRI (**d**, **e**, **f**). All images are T2-weighted MRIs. Coronal slices **b** and **c** correspond with the left and right dashed lines in image **a**. Coronal slices **e** and **f** correspond with the left and right dashed lines in image **d**. Measurements are taken at the maximum CLL diameter in any imaging plane [7, 15]

surgery. This rest period could have incidentally aided in the healing of the left knee JOCD. Another limitation is the patient did not undergo arthroscopy, which could have confirmed or refuted the imaging signs of JOCD instability seen on MRI. Being a case report, these results may not be generalizable to a larger population.

Conclusions

An athlete with radiographically unstable knee JOCD was monitored carefully with follow-up MRIs during a course of conservative care until a successful return to play. The high resolution of MRI displays the pathology and interval changes which enables measurement of the progression of JOCD. Objective measurements with high validity such as CLL size may be tracked during conservative care to recalculate healing probability. Improvements in healing probability support continued non-operative management. It is unclear if conservative therapies such as BFRT, near-infrared light, vitamins D_3 and K_2, and PEMF accelerate healing compared with activity restriction alone, and these therapies may deserve further study in JOCD populations.

Author Contributions RT conceived and designed the study and was responsible for data collection and the literature search. RT and JB wrote and revised the manuscript and analyzed and presented the results. JB interpreted radiographs and MRIs.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent As the patient was a minor, written informed consent was obtained from his parent to publish this case report and any accompanying images.

References

1. Andriolo L, Crawford DC, Reale D, Zaffagnini S, Candrian C, Cavicchioli A, et al. Osteochondritis dissecans of the knee: etiology and pathogenetic mechanisms. A systematic review. CARTILAGE. 2018. https://doi.org/10.1177/1947603518786557.
2. Andriolo L, Candrian C, Papio T, Cavicchioli A, Perdisa F, Filardo G. Osteochondritis dissecans of the knee - conservative treatment strategies: a systematic review. CARTILAGE. 2018. https://doi.org/10.1177/1947603518758435.
3. Pareek A, Sanders TL, Wu IT, Larson DR, Saris DBF, Krych AJ. Incidence of symptomatic osteochondritis dissecans lesions of the knee: a population-based study in Olmsted County. Osteoarthr Cartil. 2017;25:1663–71.
4. Salci L, Ayeni O, Abouassaly M, Farrokhyar F, D'Souza JA, Bhandari M, et al. Indications for surgical management of osteochondritis dissecans of the knee in the pediatric population: a systematic review. J Knee Surg. 2014;27:147–56.
5. Ananthaharan A, Randsborg P-H. Epidemiology and patient-reported outcome after juvenile osteochondritis dissecans in the knee. Knee. 2018;25:595–601.
6. Pill SG, Ganley TJ, Milam RA, Lou JE, Meyer JS, Flynn JM. Role of magnetic resonance imaging and clinical criteria in predicting successful nonoperative treatment of osteochondritis dissecans in children. J Pediatr Orthop. 2003;23:102–8.
7. Kijowski R, Blankenbaker DG, Shinki K, Fine JP, Graf BK, De Smet AA. Juvenile versus adult osteochondritis dissecans of the knee: appropriate MR imaging criteria for instability. Radiology. 2008;248:571–8.
8. Hughes JA, Cook JV, Churchill MA, Warren ME. Juvenile osteochondritis dissecans: a 5-year review of the natural history using clinical and MRI evaluation. Pediatr Radiol. 2003;33:410–7.
9. Yoshida S, Ikata T, Takai H, Kashiwaguchi S, Katoh S, Takeda Y. Osteochondritis dissecans of the femoral condyle in the growth stage. Clin Orthop. 1998;346:162–70.
10. Jürgensen I, Bachmann G, Schleicher I, Haas H. Arthroscopic versus conservative treatment of osteochondritis dissecans of the knee: value of magnetic resonance imaging in therapy planning and follow-up. Arthrosc J Arthrosc Relat Surg. 2002;18:378–86.
11. Krause M, Hapfelmeier A, Möller M, Amling M, Bohndorf K, Meenen NM. Healing predictors of stable juvenile osteochondritis dissecans knee lesions after 6 and 12 months of nonoperative treatment. Am J Sports Med. 2013;41:2384–91.
12. Wall EJ, Vourazeris J, Myer GD, Emery KH, Divine JG, Nick TG, et al. The healing potential of stable juvenile osteochondritis dissecans knee lesions. J Bone Joint Surg Am. 2008;90:2655–64.
13. Nakayama H, Iseki T, Kambara S, Yoshiya S. Analysis of risk factors for poor prognosis in conservatively managed juvenile osteochondritis dissecans of the lateral femoral condyle. Knee. 2016;23:950–4.
14. Cahill BR, Phillips MR, Navarro R. The results of conservative management of juvenile osteochondritis dissecans using joint scintigraphy: a prospective study. Am J Sports Med. 1989;17:601–6.
15. Uppstrom TJ, Haskel JD, Gausden EB, Meyer R, Shin Y-W, Nguyen JT, et al. Reliability of predictive models for non-operative healing potential of stable juvenile osteochondritis dissecans knee lesions. Knee. 2016;23:698–701.
16. Parikh SN, Allen M, Wall EJ, May MM, Laor T, Zbojniewicz AM, et al. The reliability to determine "healing" in osteochondritis dissecans from radiographic assessment. J Pediatr Orthop. 2012;32:e35–9.
17. Ramski DE, Ganley TJ, Carey JL. A radiographic healing classification for osteochondritis dissecans of the knee provides good Interobserver reliability. Orthop J Sports Med. 2017;5: 2325967117740846.
18. Hughes L, Paton B, Rosenblatt B, Gissane C, Patterson SD. Blood flow restriction training in clinical musculoskeletal rehabilitation: a systematic review and meta-analysis. Br J Sports Med. 2017;51: 1003–11.
19. Loenneke JP, Young KC, Wilson JM, Andersen J. Rehabilitation of an osteochondral fracture using blood flow restricted exercise: a case review. J Bodyw Mov Ther. 2013;17:42–5.
20. Ushiroyama T, Ikeda A, Ueki M. Effect of continuous combined therapy with vitamin K2 and vitamin D3 on bone mineral density and coagulofibrinolysis function in postmenopausal women. Maturitas. 2002;41:211–21.
21. Bruns J, Werner M, Soyka M. Is vitamin D insufficiency or deficiency related to the development of osteochondritis dissecans? Knee Surg Sports Traumatol Arthrosc. 2016;24:1575–9.
22. Quirk BJ, Sannagowdara K, Buchmann EV, Jensen ES, Gregg DC, Whelan HT. Effect of near-infrared light on in vitro cellular ATP production of osteoblasts and fibroblasts and on fracture healing with intramedullary fixation. J Clin Orthop Trauma. 2016;7:234–41.
23. Kamali F, Bayat M, Torkaman G, Ebrahimi E, Salavati M. The therapeutic effect of low-level laser on repair of osteochondral defects in rabbit knee. J Photochem Photobiol B. 2007;88:11–5.
24. Massari L, Benazzo F, Falez F, Perugia D, Pietrogrande L, Setti S, et al. Biophysical stimulation of bone and cartilage: state of the art and future perspectives. Int Orthop. 2019;43:539–51.
25. Cadossi M, Buda RE, Ramponi L, Sambri A, Natali S, Giannini S. Bone marrow–derived cells and biophysical stimulation for talar osteochondral lesions: a randomized controlled study. Foot Ankle Int. 2014;35:981–7.
26. Abouassaly M, Peterson D, Salci L, Farrokhyar F, D'Souza J, Bhandari M, et al. Surgical management of osteochondritis dissecans of the knee in the paediatric population: a systematic review addressing surgical techniques. Knee Surg Sports Traumatol Arthrosc. 2014;22:1216–24.
27. Freitag J, Shah K, Wickham J, Boyd R, Tenen A. The effect of autologous adipose derived mesenchymal stem cell therapy in the treatment of a large osteochondral defect of the knee following unsuccessful surgical intervention of osteochondritis dissecans–a case study. BMC Musculoskelet Disord. 2017;18:298.
28. Akman B, Güven M, Bildik C, Şaylı U, Parnianfard A, Rahimli M. MRI documented improvement in patient with juvenile osteochondritis dissecans treated with platelet rich plasma. J Prolotherapy. 2016;8:e966–70.

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