Bipolar radiofrequency ablation of tibial chondroblastomas: A report of three cases

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INTRODUCTION

Chondroblastoma is a rare benign cartilaginous neoplasm of bone. The recurrence rate is high and complications are frequent following open curettage with bone grafting which is the standard treatment for chondroblastomas. We performed radiofrequency ablation in three cases of tibial chondroblastoma using the bipolar system. One patient experienced residual pain for which repeat ablation was performed. No other complications were observed during follow-up. Radiofrequency ablation may offer an effective alternative for the treatment of selected cases of chondroblastoma. The lesion characteristics which are likely to influence treatment outcome and the advantages offered by the bipolar system are discussed.
is also being evaluated in other benign bone tumours and recently, a few studies have described its effectiveness in the treatment of chondroblastomas^{3-6}. In this article, we report three cases of chondroblastoma treated using the bipolar RF ablation system.

The study was approved by our institutional ethics committee. The decision to proceed with RF ablation over open surgery was taken in consensus with the orthopaedic surgeons taking into account the lesion size, location and potential surgical morbidity.

**CASE REPORT**

**Case 1**

A 14-year-old male presented with pain in the left knee for the past 18mo which was partially relieved with analgesics. The Visual Analogue Scale (VAS) score was 7. Radiograph and computed tomography (CT) images of the left knee revealed a 1.6 cm × 1.4 cm × 1.0 cm geographic lytic lesion with sclerotic margins in the left tibial epiphysis. There was associated thinning of the articular bone. The growth plate was open and the lesion was abutting the physis without breaching it. The lesion was hypointense on T1W images and heterogeneously hyperintense on T2W images with associated bone marrow oedema and mild joint effusion. A diagnosis of chondroblastoma was presumed based on the clinical profile and the characteristic location and imaging appearance of the lesion.

RF ablation was performed under general anaesthesia and CT guidance (Somatom Sensation 40 slice CT scanner, Siemens, Erlangen, Germany). Thin axial sections were acquired for precise localisation of the lesion. An 11G bone biopsy needle set (Osteo Site, COOK Medical, Bloomington, United States) and a hammer were used to gain lesion access. An 18G bipolar RF applicator with a 15 mm exposed tip (CelonProSurge Micro, Celon AG Medical Instruments, Teltow, Germany) and a bipolar/multipolar RF power generator (CelonLab POWER, Celon AG Medical Instruments, Teltow, Germany) were used for the ablation procedure. Since a bipolar RF system was used, grounding pads were not required for heat dispersion. As recommended by the manufacturers, pulsed RF energy was applied at a power setting of 5W until a total energy of 0.90 KJ was deposited. As claimed by the manufacturers, the RF electrode produced an ablation zone of approximately 10 mm in diameter. Repeat ablation was performed after repositioning the needle so as to encompass the entire lesion. No immediate complications were observed. Analgesics and antibiotics were prescribed and the patient was discharged the next day. No further analgesic intake was required. No complications were observed. Pre-procedural and procedural images of the patient are shown in Figure 1.

**Case 2**

A 12-year-old female presented with severe pain in the left knee for the past year (VAS = 8) which was partially relieved with analgesics. Plain radiograph and CT images of the left knee showed a geographic lytic lesion with sclerotic margins of approximately 2.5 cm × 2.1 cm × 2.0 cm in size in the proximal epiphysis of the left tibia. The growth plate was open and breached and the lesion extended into the metaphysis. The overlying subchondral bone was significantly thinned. A diagnosis of chondroblastoma was presumed considering the clinical and imaging presentation which was confirmed histopathologically from the core biopsy specimen obtained during the procedure. RF ablation was performed in a similar manner to that in case 1 under general anaesthesia using an 18G RF probe with a 15 mm active tip. A total of 3 ablations were performed at different needle positions to ensure adequate lesion coverage. The patient experienced complete pain relief (VAS = 0) 1-2 d after the procedure and remained asymptomatic during follow-up (17mo). No further analgesic intake was required. No complications were observed. Pre-procedural and procedural images of the patient are shown in Figure 2.

**Case 3**

A 55-year-old female presented with severe pain and restriction of movement of the right knee joint for the past 2 years. The pain was increasing in severity over time and the VAS score at the time of presentation was 8. Radiograph and CT images of the right knee showed a 2.5 cm × 1.5 cm × 1.8 cm geographic lytic lesion with sclerotic margins in the proximal epiphysis of the right tibia. The lesion was hypointense on T1W images, homogeneously hyperintense on T2W images with associated mild joint effusion. There was thinning of the overlying subchondral bone. Although the age of the patient was atypical for chondroblastoma, the epiphyseal location of the lesion and its typical CT appearance favoured a diagnosis of chondroblastoma over other bone pathologies occurring in this location and RF ablation was chosen as the treatment option.

RF ablation was performed in a similar manner to that in the previous cases under general anaesthesia using the 18G RF probe with a 15 mm exposed tip and a total of 3 ablations were performed to adequately cover the lesion. Core biopsy of the lesion performed during the procedure confirmed the diagnosis of chondroblastoma. The patient continued to experience similar pain of reduced intensity (VAS 4-6) following the procedure. Follow-up CT imaging showed no obvious change in lesion appearance or the development of complications during the follow-up period (18mo). Follow-up imaging (radiograph and CT) obtained at 6mo showed increased matrix ossification with no significant change in lesion size. No delayed complications were observed. The pre-procedural, procedural and follow-up CT images of the patient are presented in Figure 1.
Figure 1 Chondroblastoma of the left tibia in a 14-year-old male. A, B: Plain radiograph and non-contrast computed tomography (NCCT) axial image show a geographic lytic lesion with sclerotic margins and foci of matrix calcification in the medial tibial epiphysis; C: NCCT coronal image shows thinning of the subchondral bone superiorly (white arrow) and extension of the lesion to the physeal plate inferiorly (black arrow) which is non-fused; D: Sagittal short-tau inversion-recovery magnetic resonance (MR) image showing heterogeneous signal intensity of the lesion with surrounding bone marrow and soft tissue oedema (asterisk); E: Follow-up CT image after 6 mo showing increased mineralization of the matrix with no appreciable change in lesion size.

Figure 2 Chondroblastoma of the left tibia in a 13-year-old female. A, B: Frontal radiograph and axial computed tomography (CT) image of the left knee showing a geographic lytic lesion with sclerotic margins (arrow) involving the proximal epiphysis of the tibia; C: Coronal non-contrast computed resonance image showing the lesion with thinning of the subchondral bone superiorly (arrow) and extension of the lesion into the metaphysis inferiorly; D: CT image obtained at the time of the procedure showing the radiofrequency electrode placed in the lesion. Access tracks from a prior biopsy are also seen; E: Follow-up image after 6 mo showing increased mineralization of the matrix with no appreciable change in lesion size.
related to the procedure. A diagnosis of residual disease was made, and repeat RFA was carried out. A second RF ablation was performed 3 mo after the first procedure in a similar manner under general anaesthesia using an 18 G RF probe with a 15 mm active tip. A total of 3 ablations were performed at different needle positions. The patient experienced complete pain relief (VAS 0) following the procedure. No complications were observed during follow-up (21 mo). Follow-up imaging (radiograph and CT) performed after the second RF procedure showed increased peripheral sclerosis of the lesion with no obvious change in lesion size. Procedural and follow-up images of the patient are shown in Figure 3.

Patient and procedure details are summarised in Table 1.

**DISCUSSION**

Chondroblastomas are rare benign cartilaginous tumours commonly occurring in children and young adults between 10 and 20 years of age. They characteristically involve the epiphysis and apophysis of long bones with the proximal femur, proximal tibia and proximal humerus being the...
most commonly affected sites\(^7\). They are highly prone to recurrence following surgery due to difficult anatomical locations, inadequate tumour removal, or tumour aggressiveness\(^3\). Surgery is also associated with a risk of damage to articular cartilage and physical plate leading to premature degenerative changes and limb length discrepancies, respectively\(^4\).

RF ablation is a focal form of thermal ablation in which the deposited energy causes ionic oscillation, frictional heating and coagulation necrosis of the tissues\(^8\). In the musculoskeletal system, RF ablation is widely used in benign bone lesions such as osteoid osteoma and in bone metastasis due to high success rates, reduced surgical risks and early postoperative recovery\(^9,10\). A few recent studies have proved the effectiveness of RF ablation in the treatment of selected cases of chondroblastomas and have shown high success rates and minimal associated complications\(^11,12\). To the best of our knowledge, RF ablation of chondroblastomas using bipolar RF applicators has not been reported previously.

The bipolar RF system is considered a safer form of treatment compared to the monopolar system, since placement of grounding pads is eliminated, precluding the risk of skin burns. Additionally, the applied RF energy is confined to the treatment area in the bipolar system in contrast to the monopolar system where the energy streams out through the body in all directions, increasing the body temperature by 1-2 °C. For the same reason, metallic implants are a contraindication to the use of the monopolar system since they may be included in the electrical circuit leading to undesirable effects\(^13\). The bipolar system is also considered a more efficient form of treatment than the monopolar system. Since current flow is restricted to the probe tip, the bipolar system allows the use of higher current densities resulting in more uniform heating of tissues and the production of larger volumes of ablation\(^14\). Burdio et al\(^15\) and several other authors\(^16,17\) have established the precise and uniform nature of ablation produced by the bipolar system in vivo/animal studies. This may offer an additional advantage in the management of chondroblastomas, considering their critical location close to articular cartilage and joints.

The average size of the three lesions in the present study was 2.2 cm (longest dimension). All three lesions were located in weight-bearing surfaces (proximal tibial epiphysis) and there was associated thinning of the subchondral bone in all three patients. Considering the critical location of the lesions and the associated subchondral bone thinning, there was a risk of mechanical failure and articular surface damage following the procedure. We did not experience any complications regarding articular surface damage (collapse, osteonecrosis or chondrolysis) in the follow-up period. Intact cortical bone is a thermal and electrical insulator. Therefore, small chondroblastomas with an intact surrounding shell of bone carry a reduced risk of collateral thermal damage\(^18\). However, in large lesions, such as those treated in our study with expansion and cortical thinning, the insulating properties are greatly reduced with a substantial risk for articular cartilage damage. We believe that a restricted and precise zone of ablation produced by the bipolar system reduced the risk of collateral damage to surrounding structures. However, a larger study with a longer follow-up is required to confirm this. In the study by Rybak et al\(^19\), the largest lesion in the study developed articular collapse which they attributed to the presence of a residual viable tumour. In the study by Tins et al\(^20\), two of the four cases developed articular collapse. This was attributed to the use of multi-tined expandable electrodes which produced larger volumes of coagulation and carried an increased risk of damage to the surrounding structures. Large lesion size with thinning/breach of subchondral bone, location along a weight-bearing surface and the use of probes which produce larger coagulation zones increase the risk of articular surface damage following RF treatment\(^21\).

Petsas et al\(^22\) performed RF ablation of two large femoral head chondroblastomas (average size 2.7 cm) using multi-tined probes followed by apposition of bone grafts. Neither of the patients developed articular failure since the procedures were coupled with bone augmentation procedures. Both patients experienced clinical success.

Since chondroblastomas are epiphyseal tumours occurring in the younger population, there is risk of damage to the physis both during surgery and RF ablation. In fact, RF ablation is being evaluated in animal models as a method of producing epiphysiodesis for the treatment of limb length discrepancy and angular deformity\(^23\). Two patients (patients 1 and 2) in our study had an open growth plate and one of them had a physeal breach with extension of the lesion into the metaphysis. We did not observe any limb length discrepancy (on physical examination) during follow-up in either patient (17 and 18 mo). However, longer periods of follow-up are required to assess the occurrence of growth plate damage and limb length discrepancy, if any. The presence of a rim of bone between the lesion and the physis reduces the risk of damage to the physis\(^24\).

One of our patients (patient 3) experienced residual pain following the procedure which was likely due to incomplete tumour ablation. Repeat RF ablation was performed after which she was asymptomatic at follow-up. Chondroblastomas have a high recurrence rate ranging from 10% to 35% following surgery, and cases have been reported to recur a decade after surgery\(^25\). Hence, a larger study with a longer follow-up would be required to assess the risk of recurrence following RF ablation.

The average VAS score of the patients before the RF procedure was 7.7 (range: 7-8). All three patients experienced complete pain relief (VAS 0) in the initial few days following successful RF treatment requiring no further analgesic intake.

To conclude, RF ablation allows successful treatment of small chondroblastomas. Larger lesions carry a risk of damage to articular cartilage/growth plate and mechanical failure following RF treatment. The bipolar system
may allow treatment of larger lesions with a relatively reduced risk of damage to surrounding structures compared to the monopolar system. However, a larger study with longer follow-up is required to establish the long-term outcome of this treatment.

REFERENCES
1 Yochum TR, Rowe LJ. Essentials of Skeletal Radiology. 3rd ed. Hagerstown, MD: Lippincott Williams and Wilkins, 2005: 1280-1283
2 Ramappa AJ, Lee FY, Tang P, Carlson JR, Gebhardt MC, Mankin HJ. Chondroblastoma of bone. J Bone Joint Surg Am 2000; 82-A: 1140-1145
3 Rybak LD, Rosenthal DI, Wittig JC. Chondroblastoma: radiofrequency ablation—alternative to surgical resection in selected cases. Radiology 2009; 251: 599-604
4 Tins B, Cassar-Pullicino V, McCauley I, Cool P, Williams D, Mangham D. Radiofrequency ablation of chondroblastoma using a multi-tined expandable electrode system: initial results. Eur Radiol 2006; 16: 804-810
5 Petsas T, Megas P, Papathanassiou Z. Radiofrequency ablation of two femoral head chondroblastomas. Eur J Radiol 2007; 63: 63-67
6 Christie-Large M, Evans N, Davies AM, James SL. Radiofrequency ablation of chondroblastoma: procedure technique, clinical and MR imaging follow up of four cases. Skeletal Radiol 2008; 37: 1011-1017
7 Sepah YJ, Umer M, Minhas K, Hafeez K. Chondroblastoma of the cuboid with an associated aneurysmal bone cyst: a case report. J Med Case Rep 2007; 1: 135
8 Garin IE, Wang EH. Chondroblastoma. J Orthop Surg (Hong Kong) 2008; 16: 84-87
9 Masui F, Ushigome S, Kamitani K, Asanuma K, Fujii K. Chondroblastoma: a study of 11 cases. Eur J Surg Oncol 2002; 28: 869-874
10 Goldberg SN. Radiofrequency tumor ablation: principles and techniques. Eur J Ultrasound 2001; 13: 129-147
11 Rosenthal DI, Hornicek FJ, Torriani M, Gebhardt MC, Mankin HJ. Osteoid osteoma: percutaneous treatment with radiofrequency energy. Radiology 2003; 229: 171-175
12 Callstrom MR, Charboneau JW, Goetz MP, Rubin J, Wong GY, Sloan JA, Novotny PJ, Lewis BD, Welch TJ, Farrell MA, Maus TP, Lee RA, Reading CC, Petersen IA, Pickett DD. Painful metastases involving bone: feasibility of percutaneous CT- and US-guided radio-frequency ablation. Radiology 2002; 224: 87-97
13 Mahnken AH, Tacke JA, Wildberger JE, Günther RW. Radiofrequency ablation of osteoid osteoma: initial results with a bipolar ablation device. J Vasc Inter R Rad 2006; 17: 1465-1470
14 Nakada SY, Jerde TJ, Warner TF, Wright AS, Haemmerich D, Mahvi DM, Lee FT. Bipolar radiofrequency ablation of the kidney: comparison with monopolar radiofrequency ablation. J Endourol 2003; 17: 927-933
15 Burdio F, Güemes A, Burdio JM, Navarro A, Sousa R, Castella T, Cruz I, Burzaco O, Guirao X, Lozano R. Large hepatic ablation with bipolar saline-enhanced radiofrequency: an experimental study in in vivo porcine liver with a novel approach. J Surg Res 2003; 110: 193-201
16 Yi B, Somasundar P, Espat NJ. Novel laparoscopic bipolar radiofrequency energy technology for expedited hepatic tumour ablation. HPB (Oxford) 2009; 11: 135-139
17 Kunkel MG, Dahlín DC, Young HH. Benign chondroblastoma. J Bone Joint Surg Am 1956; 38-A: 817-826
18 Ghanem I, El Hage S, Diab M, Saliba E, Khazzaka A, Afimos G, Daigher F, Kharrat K. Radiofrequency application to the growth plate in the rabbit: a new potential approach to epiphysiodesis. J Pediatr Orthop 2009; 29: 629-635