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Neurophysiological Monitoring in Radiofrequency Ablation of Spinal Osteoid Osteoma With a Progressive Time and Temperature Protocol in Children

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Abstract

Study Design: Retrospective. Level IV Evidence.
Objective: To assess the utility of intraoperative neurophysiological monitoring (IONM) to detect and eventually prevent impending neurovascular damage during computed tomography (CT)-guided radiofrequency ablation (RFA) of spinal osteoid osteoma (OO) in children.
Summary and Background Data: To our knowledge, this is the first case series of spinal OO in pediatric patients treated at a single center employing IONM during RFA.
Methods: This is a retrospective study of seven consecutive patients (3 girls and 4 boys, mean age: 9 years 4 months) with imaging and clinical signs compatible with spinal OO who underwent CT-guided RFA, under general anesthesia, and IONM in a single center between 2011 and 2015. Before the RFA procedure, a CT-guided percutaneous biopsy of the nidus was performed in the same setting. RFA was divided into four cycles of increasing time and temperature and performed under IONM in every patient.
Results: Two patients had lesions located in the thoracic spine and five patients had lumbar involvement. The RFA technical and clinical success was 85.7%. Six patients presented with reversible neurophysiological changes either during biopsy needle positioning or RFA cycles. In the remaining case, as IONM changes did not improve after several minutes of neuroprotective hypertension, the procedure was interrupted. Neither neurologic nor vascular complications were observed after RFA treatment. In only one biopsy sample, OO was confirmed by histopathologic studies.
Conclusion: CT-guided RFA is an accepted minimally invasive technique for the treatment of spinal OO in children. IONM may be a helpful tool that requires minimal additional time and provides feedback on the state of the spinal cord and nerves at risk during the procedure. We promote the use of IONM during these procedures to detect and possibly prevent impending neurologic damage.
Level of Evidence: Level IV.

Keywords: Osteoma osteoid; Spine; Ablation; Bone; Neurophysiological monitoring

Introduction

Osteoid osteoma (OO) is a benign bone tumor relatively common in childhood and young adulthood (range 5–20 years) that produces an excessive amount of prostaglandins within its core or nidus. This pathology is characterized by severe pain that increases during exercise or occurs spontaneously during the night [1]. It was first described by

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Bergstrand et al. in 1930 [1] and Jaffe et al. in 1935 [2]. Usually, OO does not exceed 1.5 to 2 cm in diameter. Only 10% to 25% of all OO occur in the spine, the lumbar region (59%) and the posterior vertebral column (70%) being the most commonly affected sites [3-7].

According to the literature, diagnosis is usually made between 18 and 24 months after symptom onset [3,8]. The difficult pain control, the risk of compensatory scoliosis, and the development of rigid or structural curves had made surgery the treatment of choice [8-10]. Even though surgery was the gold standard [9,10], the resection of the nidus of the osteoma can be complicated by incomplete removal, residual pain [2], instability with the subsequent need for instrumentation, and vascular as well as neurologic damage [9,11]. Currently, computed tomography (CT)-guided radiofrequency ablation (RFA) has become the technique of choice for the treatment of OO [2,5-7,11-18].

The RFA heating has a cytotoxic effect on the spinal cord, peripheral nerves, and the vessels [5,9,19]. Nerve proximity to the ablation area is well known to be susceptible to damage by high temperatures. Animal studies showed no permanent nerve dysfunction at 40°C [20] and permanent nerve damage at 51°C [21]. Therefore, temperature from the local surgical field should be assessed and controlled for a safer procedure. In 2011, Maarrawi et al. recorded motor evoked potential (MEP) monitoring from rat lumbar spine muscles following RFA at various distances from the L5 nerve root, followed by necropsy to evaluate the impact of distance between the RFA cytotoxic effect and the neural tissue, revealing positive correlation between the effect of heating and tissue necrosis [22,23]. Marshall et al. demonstrated the utility, safety, and feasibility of intraoperative neurophysiological monitoring (IONM) during RFA procedures in three OO in upper and lower limbs [24]. However, no studies have evaluated the use of IONM during CT-guided RFA in spinal OO in in children.

The purpose of this study was to evaluate the role of IONM in detecting and eventually preventing impending neurovascular damage during CT-guided RFA of spinal OO in children, using a progressive and increasing time and temperature RFA-protocol.

Materials and Methods

This is a retrospective study conducted at a single center between 2011 and 2015, describing the results of seven consecutive patients with clinical signs and imaging studies compatible with spinal OO who underwent CT-guided RFA under general anesthesia and IONM. Three girls and four boys (mean age: 9 years 4 months) were treated using the same protocol. None of these patients had previously received surgical treatment. Every patient received nonsteroidal anti-inflammatory drugs previously to the procedure as a regular nonsurgical treatment.

Table
Demographic features of seven patients with osteoid osteoma who underwent radiofrequency ablation.

Case	Sex	Age (yr + mo)	Pain history (yr + mo)	Relief with NSAIDs	Spinal level	Lesional location	Lesion size (mm)	Preoperative VAS	Preoperative Scoliosis	Preoperative neurologic evaluation	FrEMG-SSEP-TcMEP event during RFA	Postoperative neurologic status	Postoperative VAS	Need of surgical intervention?	Histo pathology	Follow-up (yr + mo)
1	M	9 + 3	1 + 6	Yes	L4 left	Lamina	12.7	8	Yes	Normal	TcMEP reversible event/recovered	No new neurologic deficit	1	No	Positive	3
2	M	7 + 5	1 + 8	Yes	L4 right	Lamina	9.7	8	Yes	Normal	TcMEP reversible event/recovered	No new neurologic deficit	3	No	Negative	2 + 10
3	M	13 + 10	0 + 3	No	T1 left	Lamina	12.2	9	Yes	Normal	No event	No new neurologic deficit	1	No	Negative	1 + 9
4	F	10 + 9	1 + 6	Yes	L4 right	Pedicle	10.2	9	Yes	Right L4 paresthesia	TcMEP irreversible event L4 left/interrupted during fourth cycle	No new neurologic deficit	2	No	Negative	1 + 7
5	F	8 + 1	2 + 4	Yes	T8 left	Lateral recess	9.5	10	Yes	Left T8 paresthesia	TcMEP reversible event/recovered	No new neurologic deficit	2	No	Negative	6 + 4
6	F	4 + 1	1 + 6	Yes	L5 left	Pedicle	9	9	No	Normal	TcMEP reversible event/recovered	No new neurologic deficit	2	Yes	Negative	3 + 4
7	M	12 + 2	1	Yes	L5 left	Pedicle	6	9	No	Normal	TcMEP reversible event/recovered	No new neurologic deficit	3	No	Negative	1 + 4

FrEMG, free-run electromyography; NSAIDs, nonsteroidal anti-inflammatory drugs; RFA, radiofrequency ablation; SSEP, somatosensory evoked potential; TcMEP, transcranial motor evoked potential; VAS, visual analog scale; Yr + mo: year and month.