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Brief Communication

Incidence of 99Tc-MDP uptake in the external occipital protuberance in the pediatric population: the new normal?

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Abstract: Background: Children and young adults have a vast array of electronics at their fingertips. While it can provide endless hours of entertainment and education, we are also seeing a structural consequence. Children are using these devices with their head tilted down with poor posture resulting in increased stress on the skull from attached structures which can lead to a bone spur (exostosis) at the external occipital protuberance (EOP). While typically painless, it can progress to necessitate surgical intervention. Objectives: The purpose of this study is to understand the prevalence of exostosis at the EOP and how the finding can affect the nuclear medicine bone scan. Materials and methods: 43 pediatric patients who underwent a whole-body bone scan over a period of 1 year were included in the study (10-19 years old). Images were reviewed by 2 board-certified Nuclear Medicine physicians to assess for uptake midline in the occipital skull. Suspected cases were followed up with all available clinical and radiographic reports and images. Results: Bone scan demonstrated an occipital focus of uptake in 7 (16%) of the 43 patients (5 males and 2 females with a mean age of 15 years; range 10-19). Of these, 5/7 (71%) were confirmed by additional imaging. Conclusion: The rapidly advancing technology is leading to increased screen time in children and young adults. Our study shows that 16% of the pediatric population imaged at our facility between the ages of 10-19 years have signs of exostosis at the EOP. It is particularly important for clinicians to be aware of this entity when reading bone scans to avoid false positive interpretations.

Keywords: Bone scan, skull, pediatrics, external occipital protuberance, exostosis

Introduction

Per the World Health Organization (WHO), gaming disorder is now officially a medical condition that has been listed in the International Classification of Diseases (ICD) 11. It is defined as a pattern of gaming behavior (“digital-gaming” or “video-gaming”) characterized by impaired control over gaming, increasing priority given to gaming over other activities despite negative consequences. This is particularly true in children where 97% of teen boys and 83% of teen girls play video games, according to the Pew Research Center. It is reported that 95% of teen have or have access to a smartphone and 45% of teen now say they are online on a near-constant basis [1]. An additional factor compounding the problem has been the Covid-19 pandemic which forced school-aged kids to move to virtual learning with increased use of tablets. The stay-at home mandates and quarantines further increased the use of online gaming and handheld device usage [2, 3]. Now with the advent of Artificial Intelligence and the potential of ChatGPT entering the classroom the use of electronic devices will only increase [4]. We are now seeing a physical change in teens and young adults due to this increased use of handheld technology devices furthered by the Covid-19 pandemic [5, 6].

Ligaments, tendons and joint capsules attach to bones at an enthesis whose function is to distribute force over a large area of bone surface [7]. Repetitive stress at the enthesis can lead to an enthesophyte development to further increase the surface area of the tendon/bone interface with bone growth in the direction of the tensile stress [8]. The external occipital protuberance (EOP) is a midline bony prominence in the posterior surface of the occipital bone that the ligamentum nuchae and trape-

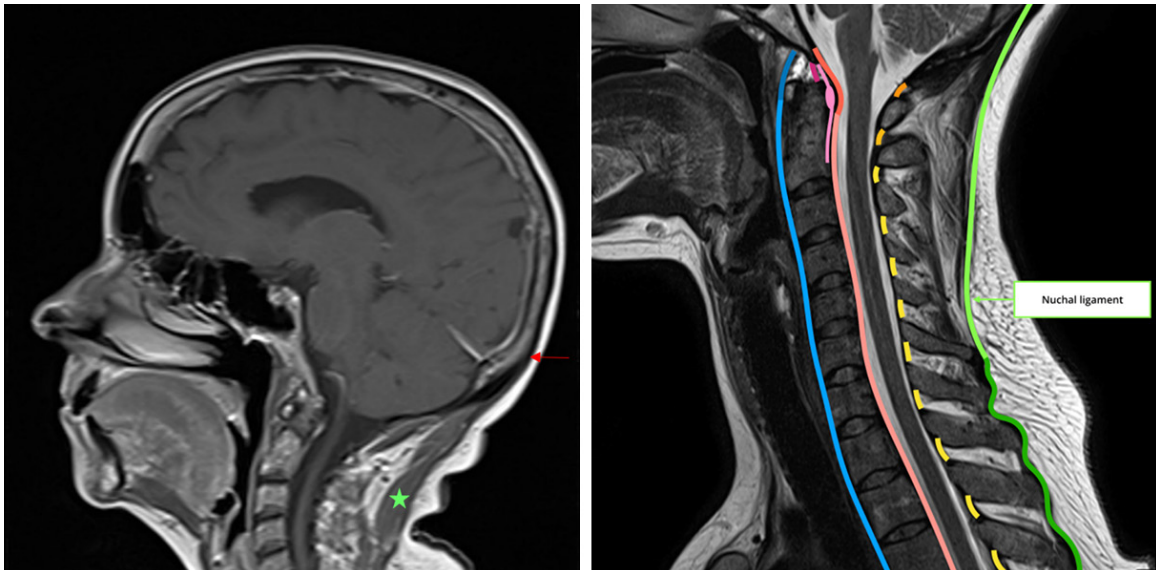

Figure 1. The ligamentum nuchae (green star on left and green line on right) attaches to the EOP (red arrow on left) and extends inferiorly to spinous process of C7. Case courtesy of Frank Gaillard, Radiopaedia.org, rID: 59206.

Table 1. Patient demographics of the 43 unique patients included in the study

Indication	# Patients	M/F Distribution	Exostosis at EOP # cases (MF)
Back Pain	15	4M/11F	3 (2M/1F)
Extremity Pain	12	2M/10F	0
Hip Pain	3	1M/2F	0
Sarcoma	13	7M/6F	4 (3M/1F)
TOTALS	43	14M/29F	7 (5M/2F)

zius muscle attach to (**Figure 1**). The ligamentum nuchae extends from the EOP on the skull and median nuchal line, to the spinous process of C7 [9]. Its function is to limit flexion and to provide an attachment for trapezius and splenius capitis muscles [10].

The extended use of handheld electronic devices leads to prolonged neck hyperflexion resulting in gradual chronic irritation. This can then develop into an enthesophyte or exostosis at the EOP [11]. On nuclear medicine bone scintigraphy, the exostosis results in a focus of increased Technetium-99m methylene diphosphonate (Tc-99m MDP) uptake mimicking skull metastases. Therefore, EOP uptake may represent a common potential pitfall in staging and restaging pediatric patients undergoing bone scanning. To the best of our knowledge, the frequency of focal uptake arising at the EOP on bone scintigraphy is not known. The purpose of this study is help clinicians become aware of this potential false-positive focus on bone scintigraphy which can affect a patient's prognosis and management.

Materials and methods

This IRB approved retrospective study included 43 sequential patients (14 males and 29 females; mean age, 14.4 years) referred for a nuclear bone scan at our Children's hospital for various indications from December 2018 to November 2019 (**Table 1**). A log was kept to record cases of focal uptake at the EOP. When available, additional supportive imaging was also reviewed including prior bone scans, PET/CT, CT and X-rays. The most prominent case of EOP was selected and the parents were contacted to describe the amount of handheld device usage and posture.

Bone scan protocol

An intravenous 9.25 MBq/kg (0.25 mCi/kg) injection of technetium 99m-methyl diphosphonate (99mTc MDP) was administered with a minimum of 1 mCi and a maximum of 17.5 mCi. Anterior and posterior whole body images were obtained 3 hours post-injection by Siemens Intevo® gamma camera (Siemens Healthcare). Additional spot views of the skull were obtained in the lateral projection.

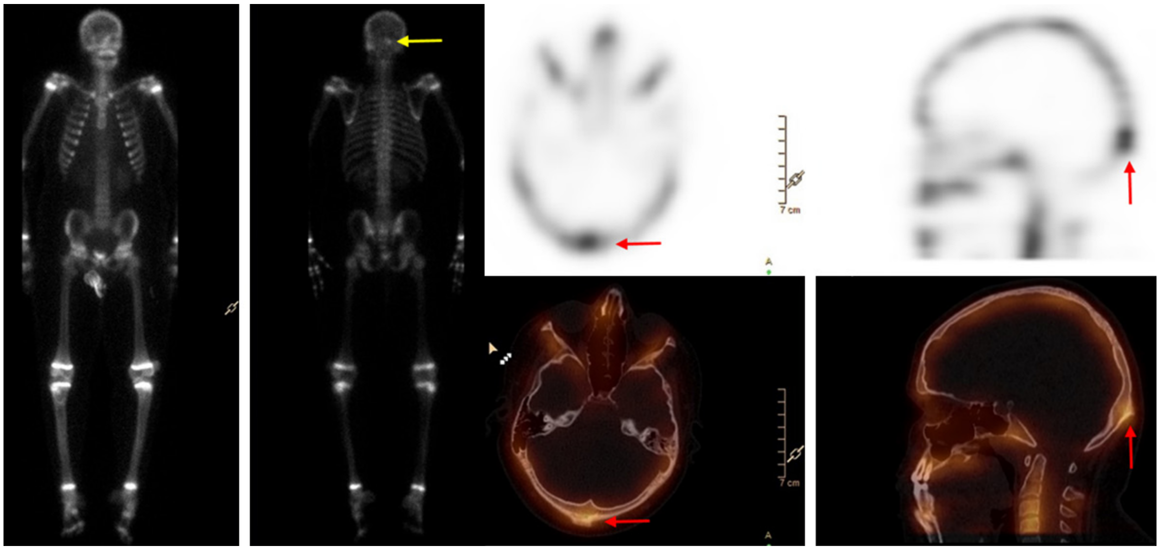

Figure 2. Whole body bone scan showing a small focus of uptake in the occipital skull (yellow arrow). SPECT/CT images were performed demonstrating the focus of uptake fusing onto a prominent EOP (red arrows).

When performed, SPECT acquisitions were done using a 128 × 128 matrix set and 1.0 zoom, with 120 views in a noncircular orbit (auto-contouring) in the continuous acquisition mode, a pixel size of 3.3 mm, and a slice thickness of 3.3 mm. The acquisition time was 10 s/step, with a total acquisition time of approximately 20 min. The SPECT images were reconstructed using Flash 3D iterative reconstruction incorporating CT attenuation correction. The photo-peak of the SPECT acquisition was set at 140 keV ± 10%. CT acquisitions were performed using a hybrid-dedicated low-dose 6-slice CT subsystem (CT acquisition and reconstruction parameters: 110 kV, mA is calculated by the CARE Dose 4D algorithm, 512 × 512 matrix, 5.0 mm slice thickness, and a pitch of 0.75). The volume computed tomography dose index varies from case to case and is based on the size of the individual patient being scanned.

Image analysis

All bone scans and SPECT-CT images were reviewed on a Philips IntelliSpacePortal Version 10.1 Workstation (Philips Healthcare) by two board certified nuclear medicine physicians. A log was kept recording cases of focal increased uptake midline in the occipital skull. Findings were subsequently confirmed after a thorough review of the medical record including clinical notes, radiology reports and images.

Results

Of the 43 patients included in the study, bone scan imaging demonstrated a focus of uptake midline in the occipital skull in 7/43 (16%; 5 males and 2 females), confirmed by both readers. The mean patient age was 15 years with a range of 10-19 years (Supplementary Table 1). Of these 7, a prior bone scan was available in 5/7 (71%) and other supportive imaging was also available in 5/7 (71%). The parents of the most prominent case of EOP (**Figure 2**) were contacted and confirmed poor posture and slouching while using handheld devices for several hours a day which had been occurring for several years.

Discussion

Bone scintigraphy remains a common nuclear medicine procedure in the diagnosis and/or management of benign and malignant tumors, infection and trauma. Techniques such as single-photon emission computed tomography (SPECT) can be used for improved spatial resolution. In addition, combined SPECT/computed tomography (CT) is used to further improve diagnostic accuracy with anatomic localization and save the patient form coming back for additional cross-sectional imaging [12]. It has been shown to be superior to both SPECT and planar imaging alone [13]. However, due to the range of normal variability in the pediatric population,

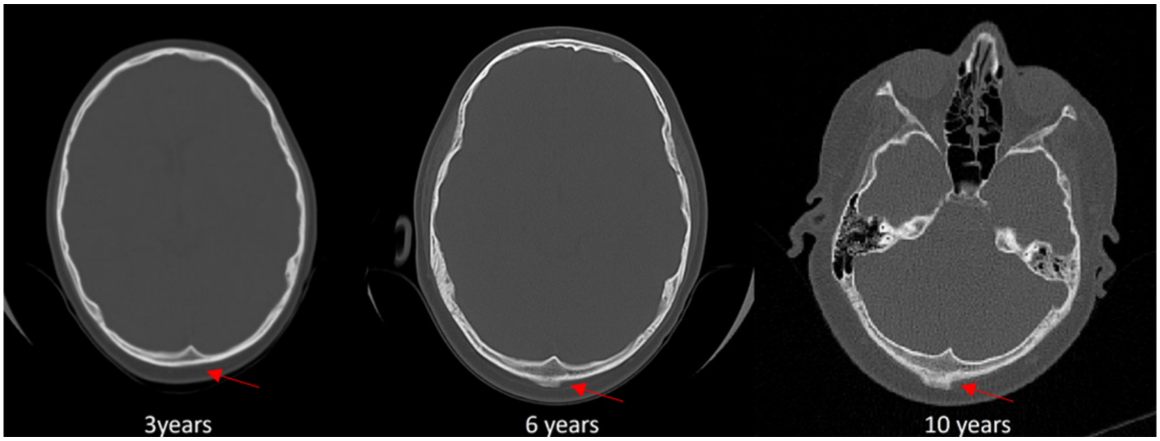

Figure 3. CT images of the skull over a span of 7 years in 10-year-old male demonstrating gradual increasing size of a small occipital protuberance (red arrow).

special care needs to be taken to decipher between a potentially pathologic abnormality versus a benign variant [14]. Upon reviewing multiple pediatric bone scans with no history of trauma, a pattern emerged with a small focus in the occipital skull. In reviewing the literature, the frequency of this finding on bone scintigraphy was unknown. In our study, the frequency of focal uptake in the occipital skull in the pediatric population was 16% of studies performed. Furthermore, with the ever-increasing use of electronics this will likely become more prevalent not only in the pediatric population but in time will be commonly seen in adults as well.

According to our review, encountering a 99mTc MDP focus of uptake in the EOP has not been well documented. However, bone scintigraphy remains one of the most common radionuclide examinations in children to identify changes in bone metabolism. A focus of uptake in an area not commonly seen can give rise to a concern for malignancy, which can affect staging and patient management. Diagnosis of EOP is primarily based on plain film radiographs or CT. EOPs are typically classified into 3 types: Type 1 is a smooth form of the EOP, Type 2 is a crest-like prominence, and Type 3 is a spine-like prominence [10, 15]. In our study, the most prominent EOP focus on bone scintigraphy was in a 10-year-old male presenting with low back pain. SPECT/CT imaging of the head was acquired which demonstrated moderate uptake midline in the occipital skull fusing onto the EOP (**Figure 2**). A baseline head CT was performed on the child when he was 4 years old due to a fall which demonstrated no abnormality. It was then repeated 3 years later again due to a fall which demonstrated interval development of a Type 2 EOP which further progressed to the time of the bone scan (**Figure 3**).

Although usually asymptomatic, these hyperostoses can lead to pain and tenderness especially when lying down. Mild cases can be treated conservatively with analgesics or botox [16]. As it progresses, some patients may have pain at rest or on neck movement. The most definitive management for these patients is surgical resection resulting in long-term resolution of symptoms and minimal scarring hidden under the hairline [15, 17].

Our study is not without limitations. The retrospective nature of the study is a potential limitation. Also, adult bone scans were not included in the review. Furthermore, additional anatomic consequences of increased screen time such as poor posture leading to back pain or increased eye strain leading to vision issues were not evaluated. The small sample size at a single institution is also a limitation as not all patients with focal uptake at the EOP had additional imaging confirmation. Lastly but most importantly, electronic use may be contributory to the increased EOP uptake, however, it is difficult to prove causation without a long-term study. This would have its own challenges due to the widespread use of electronics in order to account for a control group. Further studies can better assess the impact of focal uptake at the EOP with a larger sample size involving multiple institutions.

Conclusion

The rapid advancement in the usage and reliance on handheld devices is providing hours of daily entertainment, education and productivity. As new research continues to be published illustrating the harmful effects of increased screen time, we are struggling to impose healthy limits. Our study shows that increased MDP uptake on bone scintigraphy at the EOP is seen in 16% of the pediatric bone scans performed at our institution. At least in part, chronic use of handheld electronics may result in a hyperostosis at the EOP. Although incidental and benign, the significance of being aware of the entity is to distinguish it from metastasis, especially in patients with known malignancy.

Disclosure of conflict of interest

None.

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Supplementary Table 1. Information of all the patients

Patient	Age	M/F	Indication	Indication positivity (Y/N)
1	12	F	Back pain	Y
2	17	F	Back pain	N
3	2	F	Hip pain	Y
4	16	F	Extremity pain	Y
5	19	M	Sarcoma	Y
6	23	F	Sarcoma	Y
7	10	M	Back pain	N
8	27	M	Sarcoma	Y
9	19	F	Sarcoma	Y
10	12	F	Back pain	Y
11	4	M	Back pain	N
12	19	M	Back pain	N
13	17	F	Extremity pain	N
14	28	M	Sarcoma	Y
15	14	M	Hip pain	N
16	18	F	Sarcoma	Y
17	23	F	Sarcoma	Y
18	14	M	Sarcoma	Y
19	31	M	Sarcoma	N
20	17	F	Hip pain	Y
21	16	M	Sarcoma	N
22	16	F	Back pain	N
23	15	F	Extremity pain	Y
24	14	M	Sarcoma	Y
25	12	F	Back pain	N
26	1	F	Extremity pain	N
27	7	F	Extremity pain	N
28	15	F	Sarcoma	Y
29	4	M	Extremity pain	N
30	6	F	Extremity pain	N
31	16	F	Back pain	N
32	7	F	Extremity pain	N
33	16	F	Back pain	N
34	20	F	Extremity pain	Y
35	14	M	Sarcoma	Y
36	9	F	Extremity pain	Y
37	11	F	Extremity pain	N
38	14	F	Back pain	N
39	17	M	Back pain	Y
40	16	F	Back pain	N
41	9	M	Extremity pain	N
42	6	F	Back pain	N
43	17	F	Back pain	N