PICTORIAL ESSAY   MSK Imaging

Beaks and peaks in adult skeleton, Part I: Bony excrescences in skull base and upper extremity

Zehra Akkaya, Ayşegül Gürsoy Çoruh, Gülden Şahin

Ankara University, School of Medicine, Department of Radiology, Ankara, Turkey

ABSTRACT

Bony protrusions which may be part of normal or variant anatomy or de novo pathologic conditions can have particular imaging and clinical findings. They can arise as a result of overuse injuries and trauma. Additionally, some bony spurs may have an evolutionary base. Some of them can result from a previous injury whereas some others are the reason for the injury of neighbouring structures themselves. Presenting symptoms may also vary accordingly, from being asymptomatic, where the lesions are detected incidentally, to being associated with severe pain and limited range of motion due to impingement and mass effect on the surrounding tissues. The purpose of this pictorial review is to overview some common and some infrequent but important bony excrescences, by emphasising on their clinical importance and differential diagnoses based on their imaging findings. This first part of the review covers the skull base and upper extremity with emphasis on the latter.

CORRESPONDING AUTHOR, GUARANTOR

Zehra Akkaya,
Ankara University, School of Medicine, Department of Radiology, Keklikpinari mahallesi Dikmen caddesi 913. Sokak Turtaş Sitesi A-8 Blok No:14
Çankaya-Ankara, Turkey, Email: zehraakkaya@gmail.com

Introduction

Adult human skeleton has numerous bony protrusions, ridges, crests and tubercles which are common sites of apophyses and entheses. These sites might be involved in various degenerative, inflammatory or overuse trauma related disorders, where they undergo hypertrophic changes.

Moreover, acquired or congenital exophytic bony lesions, variations of normal anatomic bony excrescences in particular locations may be of clinical relevance, which can shed light to the diagnosis in the right clinical context.

Radiologists are often quite familiar with these structures. However in some cases, distinguishing between a normal bony excrescence and a pathologic condition can be difficult for inexperienced eyes. A classic example is the "pseudotumour deltoideus", which refers to the spectrum of anatomic variants at the level of deltoid tubercle of humerus [1]. Furthermore in some cases, these bony excrescences may appear subtle, thus may be missed on standard radiographs unless special projections or cross sectional imaging modalities are used [2-4].

The purpose of this review is to make radiologists familiar with imaging findings related to various benign bony excrescences in the adult skull base and upper extremity, with special attention to those associated with clinical relevance or those posing a challenge in the diagnostic workup with emphasis on appendicular skeleton.
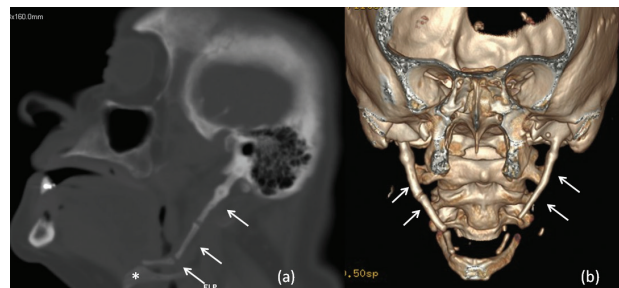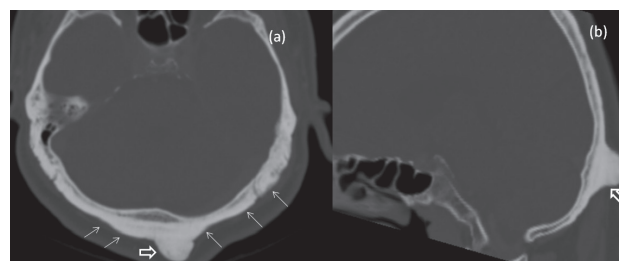
1. Skull base

1.1. Eagle syndrome

Eagle syndrome is associated with an abnormally long (more than 3 cm) styloid process or ossification of stylohyoid ligament **(Fig. 1)**. It is more common in women and uncommon before 30 years of age [5]. Depending on the anatomical structure the elongated styloid process impinges on, a wide range of clinical findings have been reported, such as glossopharyngeal neuralgia, kinking and compression of internal carotid arteries, Horner syndrome and syncope [5-8]. Computed tomography (CT), particularly 3D volume rendered and reformatted images, is the most robust diagnostic modality, where additional surgical planning and precise measurements can be performed with high accuracy [8].

1.2. Calvarial osteomas

Osteomas represent abnormally dense new bone forma-

Fig. 1. Sagittal oblique reformatted (**a**) and coronal volume rendered (**b**) CT images of a 77-year-old female patient with dysphagia reveal bilateral abnormally long styloid processes and ossification of stylohyoid ligaments (arrows), compatible with "Eagle" syndrome. Note that the calcified ligament ends at the upper border of hyoid bone (asterisk in **a**) on the left side.

Fig. 2. Axial (**a**) and sagittal reformatted (**b**) cranial CT images of a 74-year-old male patient with a painless hard lump at the back of his head are shown. The images depict an osteoma (open arrow) arising from the posterior table of the occipitoparietal bones at the site of external occipital protuberance. Note the associated posterior table thickening around the lesion (arrows). At the four-year follow up, the lesions remained stable and the patient pain free.

tion in the periosteum. They predominate in the craniofacial bones, especially in the ethmoid and frontal sinuses. In addition, they can arise from the inner and outer tables of the cranial vault, mandible and maxilla. They are commonly encountered in the fourth or fifth decades of life and are asymptomatic, unless they encroach on nearby structures, causing mass effect. On imaging they appear as smoothly contoured, homogeneous, densely sclerotic nodular bone lesions without soft tissue component, on the surface of a parent bone or within craniofacial sinuses **(Fig. 2)**. On follow up they usually remain unchanged. Differential diagnosis includes parosteal osteosarcoma, ossifying parosteal lipoma and myositis
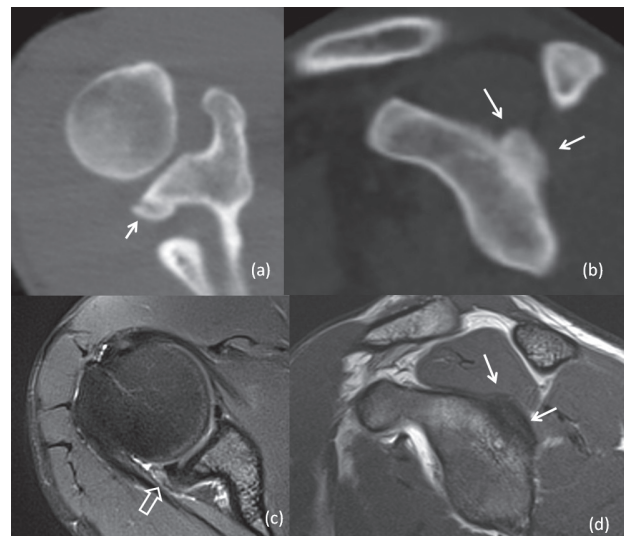
Fig. 3. Lateral cervical radiograph of a 24-year-old male patient who was referred for imaging after a fall. Note the enlarged external occipital protuberance (arrow) in this young patient. Unlike an osteoma (Fig. 2), an enthesophyte is pointy in appearance and is not associated with outer table thickening.

Fig. 4. 20-year-old professional male volleyball player who complains of posterior right shoulder pain during spiking. Axial (a) and oblique sagittal reformated (b) CT images and corresponding axial fat suppressed proton density (c) and oblique sagittal T1-weighted (d) images of his right shoulder reveal a bony spur (arrows) and associated capsular oedema (open arrow in c) on the posterior rim of the glenoid, compatible with a Bennett lesion.

ossificans [9].

1.3. Enlarged external occipital protuberance

External occipital protuberance or the "inion" can be a site of enthesophyte formation [10]. Unlike most enthesophytes or ligament ossifications, which are commonly considered to be associated with ageing, enlarged external occipital protuberance (longer than 1 cm on lateral radiographs) (Fig. 3) has been reported to occur more commonly in patients between the ages of 18-30, particularly in males [10, 11]. Additionally, forward head protraction was found to be associated with enlarged external occipital protuberance, where with increased degrees of protraction, the likelihood of having an enlarged external occipital protuberance increases [10]. Forward head protraction was lower in patients imaged prior to hand-held technology revolution, thus it is sug-

gested that increased forward head protraction could be related to higher mechanical loading on posterior craniocervical soft tissues [10, 12].
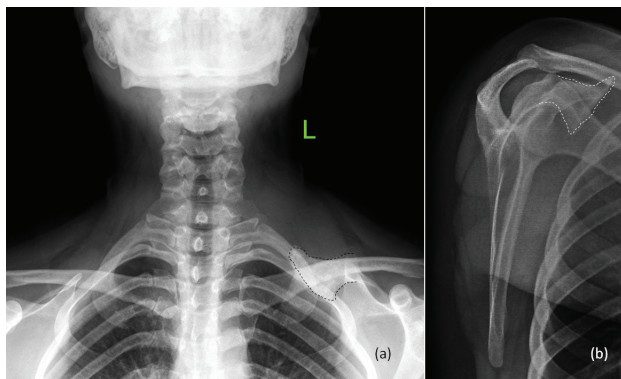
2. Upper Extremity
2.1. Scapula
2.1.1. Bennett Lesion

Bennett lesion, originally described in baseball players as an extraarticular exostosis at the posteroinferior border of the glenoid, in the proximity of posterior inferior glenohumeral ligament, is now accepted to be associated with several overhead activities [4, 13, 14]. Radiographically, it can be diagnosed on axillary, Bennett, or Stryker notch views [4].

On plain films and CT it appears as a crescent shaped mineralisation at the posterior inferior rim of the glenoid process where posterior capsule and posterior bundle of inferior glenohumeral ligament attach [15]. CT is more sensitive for the detection of the capsular mineralisation. However, magnetic resonance imaging (MRI) can detect symptomatic or early Bennett lesion with soft tissue oedema at the non-mineralised posterior glenoid process or periosteal enthesopathic change (Fig. 4) [16].

Fig. 5. *Anteroposterior cervical (**a**) and lateral scapular (**b**) radiographs of a 33-year-old female patient with pain and crepitation upon abduction of the left shoulder reveal an exostotic bony mass (dashed line) originating from the ventral surface of the upper scapula.*

Fig. 6. *Axial (**a**) and coronal oblique reformatted CT images (**b**) of the left scapula of the same patient as in **Fig. 3** demonstrate the close relationship of ventral scapular osteochondroma (arrows) with the posterior aspect of the second rib (open arrow) and its origin from the medial ventral surface of the scapular body. On axial T2-weighted MR image (**c**) and corresponding fat suppressed contrast enhanced T1-weighted image (**d**), the adventitial bursitis around its tip is seen as a fluid-filled sac with thin septal and wall enhancement (curved arrows).*
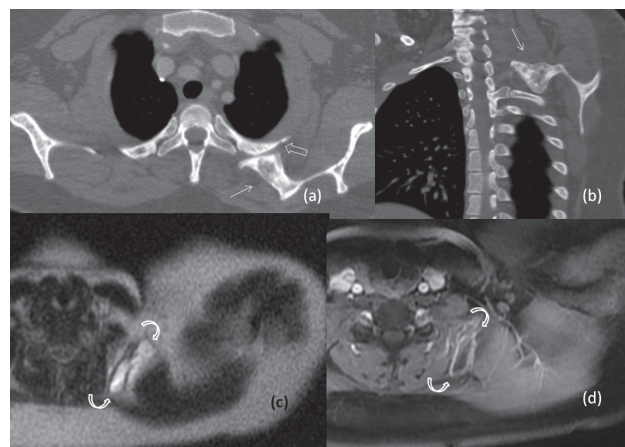
Although, according to recent literature, Bennett lesion has been only associated with higher incidence of posterior glenoid cartilage injuries, a high index of suspicion regarding the presence of concomitant abnormalities, such as posterior labral tear or degeneration which are frequently seen in overhead athletes, should be maintained. Because of its extraarticular location the ossification may not be identified during arthroscopy. MRI, with its superiority in depicting soft tissue changes such as oedema, labral tears and paralabral cysts, could be particularly useful in detecting earlier changes [17].

Treatment options include operative and non-operative methods but presence of coexisting joint derangements should be taken into account while planning treatment [13].

2.1.2. Ventral scapular osteochondroma
Solitary osteochondromas, also known as osteocartilagenous exostoses, are the most common tumours or tumour-like lesions of the bone, comprising 20-50% of all benign osseous tumours. Being considered as developmental physeal growth plate cartilage disorders, they typically appear as bony projections arising from the bone surface and in corticomedullary continuity with the underlying bone [18, 19].

Although clinically the majority of solitary osteochondromas are asymptomatic, possible symptoms and complications include cosmetic deformity, slowly growing non-tender mass, bony deformity, vascular compromise, nerve compression, overlying bursa formation and rarely
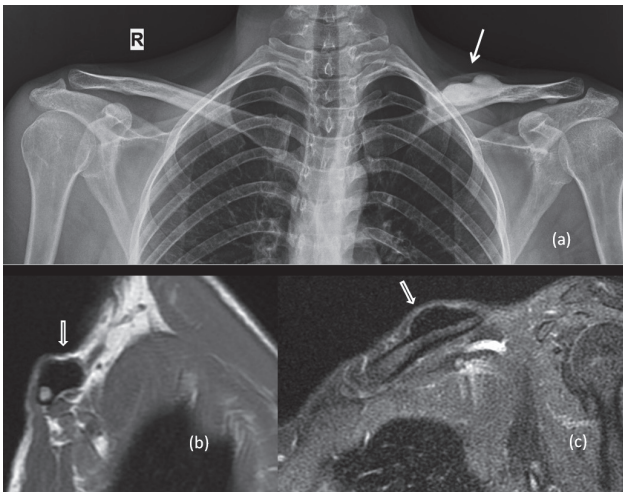
malignant transformation [18, 20]. If not part of the hereditary multiple osteochondromatosis syndromes, osteochondromas are usually solitary and most commonly found in long bones, particularly around the knee joint [18, 20-22]. However any bone that develops by enchondral ossification may harbour an osteochondroma, with the scapula being one of them, with a 4% prevalence [21]. Patients with a ventral scapular osteochondroma can present with painful and limited abduction of the shoulder, pseudo-winging and snapping scapula and bursitis between the posterior thoracic wall soft tissues and even erosions of the opposing rib cage **(Figs. 5, 6)** [23, 24].

As with other flat bones, the complex anatomy may render the delineation of the lesion on plain radiographs difficult, mandating the use of CT and/or MRI for accurate diagnosis. MRI may also play an important role in the accurate discrimination of a bursa from the cartilage cap of an osteochondroma [18]. The usual treatment of choice is surgical removal of the lesion [22, 24].

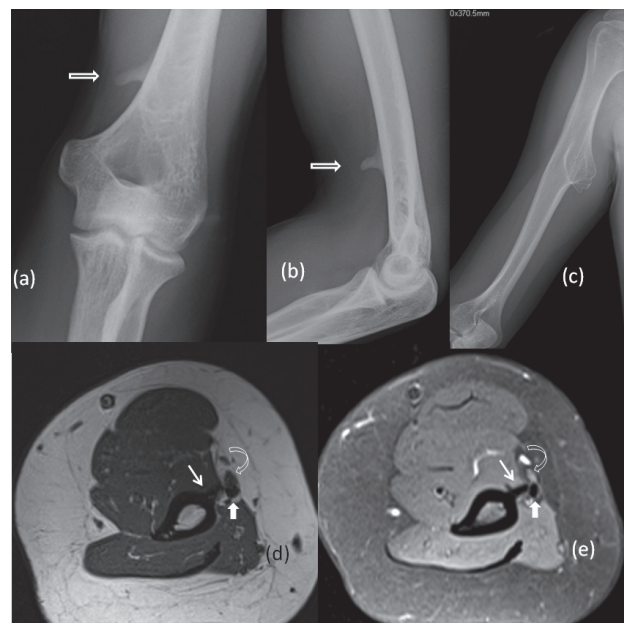### 2.2. Clavicula
2.2.1. Parosteal osteoma
Osteomas are benign compact bone tumours that rep-

Fig. 7. *Anteroposterior bilateral clavicula radiograph* **(a)** *of a 25-year-old female patient with a painless palpable mass on the left supraclavicular fossa reveals a calcific mass (arrow) with smooth but lobulated contours on the upper surface of the left clavicula in continuation with the cortical bone. The sagittal T1-weighted* **(b)** *and coronal oblique fat suppressed contrast enhanced T1-weighted* **(c)** *MR images demonstrate a well-demarcated hypointense parosteal mass (open arrows), compatible with compact bone, without involvement of the underlying bone marrow. No soft tissue or cartilage components were observed. The lesion remained unchanged over a period of 5 years' follow up.*

Fig. 8. *Anteroposterior* **(a)** *and lateral* **(b)** *elbow radiographs of an 18-year-old male patient with supracondylar spur of the humerus (open arrows) demonstrate the bony spine originating from the distal medial cortex of the humerus. Note that, unlike the osteochondroma in another patient* **(c)**, *the supracondylar spur shows no medullary bone continuity. On axial T1- weighted* **(d)** *and fat suppressed proton density MR images* **(e)** *of another patient the spur is very inconspicuous (arrows) and can easily be missed, since it consists entirely of compact bone. Yet, MRI, especially non-fat suppressed images, is useful to delineate its relationship with the brachial artery (thick arrows) and median nerve (curved arrows).*

resent focally abnormal intramembranous osseous proliferation [20]. Osteomas originating from the clavicle, scapula, innominate bone or tubular bones are sometimes referred to as parosteal osteomas **(Fig. 7)** [9]. Here they tend to be larger in size [25, 26]. In the presence of multiple osteomas, Gardner syndrome should be suspected. In addition to osteomas of the long bones, this syndrome is characterised by precancerous colonic polyps and soft tissue tumours [27]. Solitary osteomas of the long bones should be carefully differentiated from parosteal osteosarcoma, which is a malignant bone-forming tumour with a better prognosis than classic osteosarcoma [28]. In a large series of parosteal bone forming lesions, the incidence of parosteal osteosarcoma to osteoma was reported as 16:1 [29]. On imaging osteomas typically appear as uniform sclerotic masses with smooth or lobulated borders at the surface of a long bone, particularly at its diaphysis or metadiaphysis [29-32].

Lack of underlying medullary bone invasion, soft tissue component or cortical destruction favour the diagnosis

of osteoma. On scintigraphy, in contrast to parosteal osteosarcomas, osteomas show only mild radiotracer uptake on delayed images and no uptake on blood-flow or blood-pool images [32]. Still biopsy may be required for definitive diagnosis [31]. Other lesions that should be considered in the differential diagnosis of a long bone osteoma include tumoural calcinosis, osteochondroma, parosteal chondrosarcoma and myositis ossificans [26].

2. 3. Humerus
2.3.1. Supracondylar spur

Supracondylar spur of humerus **(Fig. 8)**, a bony spine approximately 5 cm above the medial epicondyle on anteromedial aspect of distal humerus, is a vestigial structure in humans with an incidence ranging between 0.4 to 2.7% in different reviews. An associated fibrous band, named

Fig. 9. Anteroposterior humerus radiograph of a 51-year-old male patient with shoulder pain radiating to the deltoid region at inital presentation. Note that the deltoid tuberosity is hypertrophic with cortical thickening at this location. The patient was diagnosed with rotator cuff disease in his shoulder MRI (not shown here) and responded well to conservative treatment.

Fig. 10. Anteroposterior radiograph of a 24-year-old female patient who presents with ulnar-sided left wrist pain demonstrates an elongated ulnar styloid process which is measured as 7.4 mm from its base. Please note that the patient has a slight negative ulnar variance.

as Struthers' ligament, which may undergo ossification, may accompany this spur as a cause of brachial artery and median nerve entrapment, giving rise to "supracondylar spur syndrome" [33, 34]. Differential diagnosis includes humeral osteochondroma **(Fig. 8d)**. However, the absence of corticomedullary bony continuity or cartilage cap in supracondylar spur can be diagnostic clues. Additionally, the direction of the tip of the supracondylar spur is pointed inferiorly towards the elbow joint, as opposed to distal humeral osteochondroma which typically points away from the elbow [35].

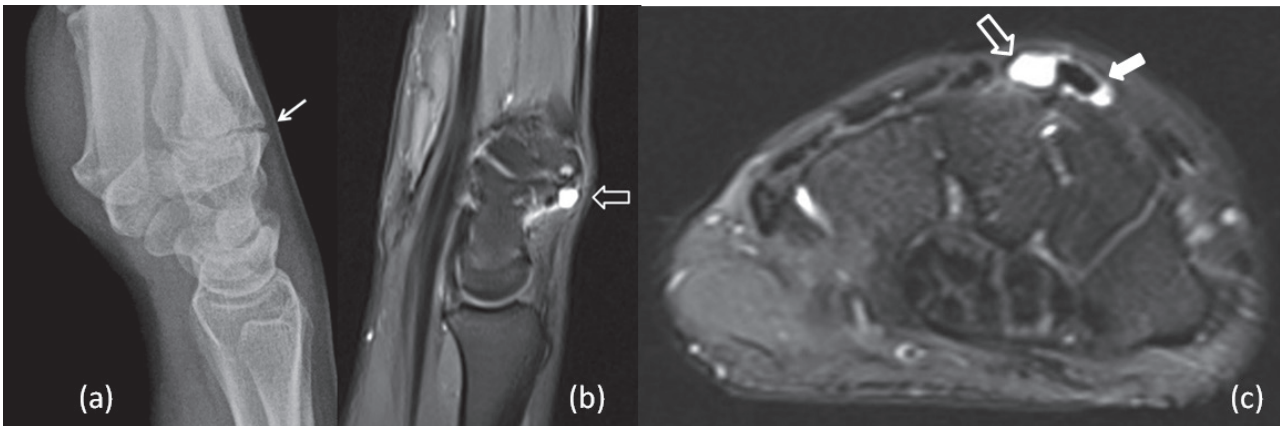### 2.3.2. Pseudotumour deltoideus

Deltoid tuberosity has various radiologic variations, which may mimic tumours or infection. Pseudotumour deltoideus represents a range of such variants at the deltoid muscle insertion site on the humerus **(Fig. 9)**. These entities include tendonitis-related erosions, avulsive cortical irregularity, herniation pits and ac-

centuated deltoid insertional anatomy. Additionally, benign bone neoplasms such as non-ossifying fibroma and fibrous dysplasia, may also be encountered in this location. Pseudotumour deltoideus can be especially suspicious for malignancy when there is uptake in bone scintigraphy and the patient presents with pain at this location [1].

2.4. Ulna
2.4.1. Elongated ulnar styloid process

The distal tip of the ulnar shaft is usually 2-6 mm in length. When it is longer than 6 mm it can be associated with "ulnar styloid impaction syndrome" where clinically patients experience ulnar sided wrist pain **(Fig. 10)**. Excessively long ulnar styloid process impacts on the triquetrum, resulting in bony contusion, synovitis, chondromalacia and damage to the lunotriquetral ligament. Adding to clinical assessment and radiographs, MRI plays a crucial role in diagnosis due to its superb ability to de-

Fig. 11. *Lateral radiograph (**a**) and sagittal fat suppressed proton density MR images (**b**) of the right wrist of a 38-year-old female patient with pain and recurrent mass after a prior excision of a dorsal ganglion cyst. Note the degenerative changes and hypertrophic bony margins at the carpometacarpal joint (arrow in **a**) and associated recurrent ganglion cyst (open arrow in **b**). On axial fat suppressed T2 weighted MR image (**c**), the ganglion cyst (open arrow) is shown along with extensor carpi radialis brevis tenosynovitis (thick arrow).*

Fig. 12. *Lateral (**a**) and posteroanterior (**b**) radiographs and axial CT image (**c**) of a 18-year-old female patient with Turret exostosis (arrow) on her third middle phalanx. The lesion appears as a sessile osteochondroma on the dorsal cortical surface of the bone. The patient complains of the mass for the past two years but has no recollection of prior trauma.*

lineate alterations of the articular cartilage, ligaments and subchondral bone. Treatment includes resection of the distal styloid process, with preservation of its proximal 2 mm segment where the triangular fibrocartilage complex inserts [36].

2.5. Tubular bones of the hand
2.5.1. Carpal boss
It is defined as a bony protuberance at the dorsal carpometa-carpal region involving the base of the second and third metacarpals [37]. Degenerative osteophyte formation, with or without the presence of an os styloideum (an accessory ossification centre that arises during embryonic development), may play a role in the process. Most of the symptoms associated with carpal boss are thought to be caused by a degenerative osteoarthritic process, a ganglion or an inflamed bursa that may develop over the bony prominence, or an extensor tendon slipping over it **(Fig. 11)** [3].

Imaging plays an important role in suspicious cases. In addition to standard anteroposterior radiographs of the hand, "carpal boss view" can be of significance. This radiograph is a modified lateral view of the wrist with the hand flexed and supinated 30° to 40° and the ulnar deviated 20° to 30° [37, 38]. CT and MRI can aid in differential diagnosis and diagnosis of associated complications.

2.5.2. Turret exostosis and Nora lesion
Turret exostosis is a dome-shaped parosteal bone proliferation located at the dorsal aspect of the phalanges **(Fig. 12)**. It most commonly involves the proximal and middle phalanges. Patients complain of a hard, sometimes painful, lump on the dorsal aspect of their fingers and generally mention previous trauma [18, 39].

Bizarre parosteal osteochondromatous proliferation (BPOP) is an uncommon reactive mineralising mesenchy-

mal lesion that typically affects the surfaces of the proximal and middle phalanges, metacarpal and metatarsal bones of the hands and feet, maintaining an intact cortex and causing no medullary change [40, 41]. Humerus, radius, ulna, tibia, femur and clavicle may rarely harbour this lesion too [42-47]. Another condition that may have a similar aethiopathogenesis along with imaging and clinical findings is florid periostitis [18, 48].

Some researchers argue that BPOP, also known as Nora lesion, florid periostitis and Turret exostosis are all part of the same disease spectrum. Nora lesion, which is considered as a reparative process, may represent an intermediate lesion between florid reactive periostitis and Turret exostosis [49, 50]. According to this, the natural evolution of the lesion which usually takes about six months, starts with florid reactive periostitis (stage 1), followed by formation of a calcified periosteal mass (stage 2) and eventually an acquired sessile osteochondroma (stage 3 or Turret exostosis). Recurrence after incomplete resection may occur, thus resection or biopsy is not recommended in early stage disease [41, 51].

Because of frequent postoperative recurrence and recent data showing repeating cytogenetic abnormalities in some cases of BPOP (a t(1;17) chromosomal translocation and inversion of chromosome 7), some researchers argue that it represents a true neoplastic process [52, 53].

Discussion

This review addresses some of the common and some uncommon but clinically important bony excrescences of the upper extremity and skull base. Exostoses, also known as osteochondromas, are by far the most common exophytic benign bony masses in the body and represent an endochondral hyperplasia, in which the bone produced has both the trabecular and cortical components. A cartilage cap might be present on their surface, which is usually only a few millimetres in thickness or even absent in the adult skeleton [18, 20-22, 54].

Spurs on the other hand are spine-like bony protuberances composed only of compact bone. The most common example of an acquired bony spur is the osteophyte, the hallmark of osteoarthritis [55-57]. When osteophytes are encountered in relatively younger patients or at specific traction sites, such as posterior glenoid margin, a history of overuse trauma or sports related injury should be inquired. Recent studies indicate that extensive use of hand-held technologies may be linked to large enthesophytic bony changes in peculiar locations, such as the calvarium in relatively young population [10, 12]. A rare example of a congenital spur is the supracondylar spur of the distal humerus, which is believed to be a vestigeal form of supracondylar canal or foramen in more primitive primates [33].

Normal anatomic excrescences of the bones may also be a cause of a wide range of painful clinical syndromes when they are larger in size than they should be [3].

The last group of benign lesions which can present as a bony excrescence addressed in this review are the parosteal bone-forming lesions encompassing parosteal osteoma, Turret exostosis, BPOP and florid periostitis. Characteristic imaging findings, along with location of lesion, history and clinical symptoms, can also be very useful in the differential diagnosis of parosteal osseous masses [25, 41, 51, 58]. Still, in selected cases with atypical clinical or radiological findings, biopsy should be warranted to rule out parosteal osteosarcoma [28, 59]. **R**

Conflict of interest
The authors declared no conflicts of interest.

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