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A circular depression at the spinoglenoid notch of a prehistoric Andean scapula: Plausible evidence of suprascapular nerve entrapment by a paralabral cyst

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ABSTRACT

While intraosseous cysts have been described in the paleopathological literature, it is rare to find reports concerning effects of soft tissue cysts, although they are relatively common in clinical contexts. Here we present plausible evidence of an extraosseous paralabral cyst, seen in an adult scapula from a Late Intermediate period commingled tomb (ca. AD 1200) at the northern highland site of Marcajirca, Ancash, Peru. The scapula demonstrated a smooth-sided concave depression at the spinoglenoid notch. The depression was notable for its regular appearance, with no bone deposition or destruction. Rather than reflect an intraosseous pathology, the defect likely resulted from pressure erosion from a space-occupying mass. A narrow strip of flattened bone connected the depression to the posterior-superior aspect of the glenoid. The location and morphology of the depression and its connection with the glenoid are consistent with the effects of a paralabral cyst that arose secondary to a tear of the posterior-superior glenoid labrum. A labral tear may act as a one-way valve permitting fluid to flow along a path of least resistance, often to the spinoglenoid notch. A cyst at the spinoglenoid notch would compress the suprascapular nerve, causing weakened function of infraspinatus and its eventual atrophy.

1. Introduction

Though cysts are clinically common, their effects on human skeletal remains have infrequently been described in the paleopathological literature. While intraosseous cysts have occasionally received attention, there are few reports detailing the effects of extraosseous cystic masses that occur in soft tissue. Paralabral cysts of the posterior shoulder often arise subsequent to a posterior-superior tear of the glenoid labrum, which allows joint fluid to extrude into the adjacent soft tissues, where it moves along a path of least resistance. Often progressive in their pathology, these space-occupying masses are most commonly found at the spinoglenoid notch, where they compress the neurovasculature and can cause pressure erosion of the subjacent bone. The most common presentation of patients with paralabral cysts is shoulder pain, weakness in external rotation of the glenohumeral joint (GHJ), and eventual atrophy of the muscle infraspinatus.

This investigation describes a circular, concave depression at the spinoglenoid notch of a scapula recovered from Marcajirca, a highland site located on a steep mountain slope in Ancash, Peru (Fig. 1). This site consists of residential, public, and funerary areas (Ibarra Asencios, 2009). Ongoing investigations have found commingled human skeletal remains in 22 funerary caves and 35 walled tombs (*chullpas*), some of which have been archaeologically tested. Radiocarbon dates of wood samples from tomb roofs (^{14}C date of 865 ± 40 BP, Cal 875 to 742 BP, YU-865, wood) and skeletal remains (^{14}C date of 840 ± 40 BP, Cal 796 to 717 BP, LTL-3853 A, human tooth; ^{14}C date of 430 ± 15 BP, Cal 512 to 499 BP, UCI-185296, human phalanx) place the *chullpas* within the Late Intermediate Period (AD 1075–1450), a volatile time in the Andes (Arkush and Tung, 2013). At Marcajirca, volatility is suggested by the defensive site location, walls along the borders of the site, the presence of slingstones and maces, and evidence of cranial trauma and trepanations (Titelbaum et al., 2013; Verano et al., 2016).

The purpose of this report is to perform a differential diagnosis of the depression, explain how it arose, and discuss how it would have affected the individual, with consideration of the anatomy of the posterior shoulder.

2. Materials and methods

Six commingled *chullpas* at Marcajirca have yielded a total of 306 (145 right, 161 left) scapulae, representing a minimum number of 111 adult and 50 subadult individuals. Adult bones were identified as having complete epiphyseal fusion (Scheuer and Black, 2000). The scapulae were in reasonably good condition, with variable damage to

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Fig. 1. Location of Marcajirca, Peru. Modified from Huhsunqu (2009).

the bodies.

Each bone was inspected for bone formation/loss, abnormalities of shape/size, fractures, developmental anomalies, and degenerative changes, in accordance with Buikstra and Ubelaker (1994). For adult bones, relative age was assessed by the absence/presence of degenerative joint disease (Aufderheide and Rodriguez-Martin, 1998). Although sex could not be determined with certainty, consideration was given to differences of size and robusticity among the sample, since sexual dimorphism has been observed at other Prehispanic sites in Peru (Verano, 1997; Farnum and Benfer, 2004; Verano, 2003; Titelbaum and Verano, 2017). Radiography was not available at the time of investigation.

3. Results

During analysis, it was noted that one partial adult left scapula demonstrated a pathological circular depression. Though the scapula was missing a portion of its body and medial border due to postmortem damage, the remainder was in good condition. Based on size, robusticity, epiphyseal fusion, and lack of degenerative changes, the scapula was likely from a young adult male. No other skeletal elements could be positively associated with the individual.

3.1. Description of the pathology

The lesion was a circular, smooth-sided, concave depression on the posterior-lateral aspect of the scapula. Located between the base of the scapular spine and the glenoid rim at the spinoglenoid notch, it measured approximately 18 mm in diameter and 5 mm deep. There was no evidence of bone deposition, bone destruction, or increased vascularization (Fig. 2). In addition to the concavity, there was a narrow strip of flattened bone that extended between the depression and the posterior-superior edge of the glenoid rim (Fig. 3). Aside from the depression and the shallow extension to the glenoid rim, no other pathological changes were observed.

Fig. 2. Left scapula with circular depression at the spinoglenoid notch.

4. Differential diagnosis

Other than the actual concavity, the defect was notable for the lack of pathological changes. The regularity of the cortex argues against intraosseous and inflammatory pathologies, the lack of bone remodeling and degenerative changes does not suggest a healed fracture or joint disease, and the defect bears no similarity to known developmental anomalies.

Rather than reflect a pathological process intrinsic to bone, it is more likely the lesion reflects a response to the presence of a space-occupying mass. Indeed, the most likely cause of the depression was pressure erosion from a slow-growing, chronic mass (Monsees et al., 1985). Pressure from a mass may stimulate subperiosteal osteoclastic activity, especially when in proximity to the periosteum (Ragsdale et al., 2017). The osteoclastic activity is accompanied by endosteal osteoblastic deposition, and the result is that the pressure erosion appears as a smooth, shallow, and well-defined defect. In imaging, margins of pressure erosions are often sclerotic, attesting to bone remodeling over a long period of time (Monsees and Murphy, 1985). Importantly, pressure is exerted on the underlying bone without disrupting the periosteum or causing cortical destruction.

There are various pathologies that can lead to pressure erosion. However, in a clinical context, when a space-occupying mass is observed at the spinoglenoid notch, the most likely conditions to consider are hematomas, arterial aneurysms, venous varices, tumors, and cysts (Blankenbaker and Davis, 2016).

4.1. Hematoma

Hematomas form when blood extravasates from a vessel into surrounding tissue, which may lead to swelling and compression of adjacent structures. Typically, hematomas arise secondary to trauma, but can also occur spontaneously (e.g., Heller et al., 2000). Blood vessels usually repair fairly quickly through clotting, however if the bleed persists, the hematoma will continue to enlarge. In the present case, a

Fig. 3. Detail of the circular depression. Arrow indicates flattened area on posterior-superior aspect of glenoid margin.

trauma-induced hematoma is unlikely since the suprascapular vasculature is relatively well protected by the overlying musculature, and there is no evidence of a fracture. The possibility for a chronic hematoma, and one that could cause localized pressure erosion of bone, is also unlikely.

4.2. Arterial aneurysm

An arterial aneurysm occurs when the wall of an artery weakens and a localized dilation of the vessel develops. The dilation may enlarge over time, and is at risk for rupture. Aneurysms may arise due to atherosclerotic, congenital, traumatic, inflammatory, or infectious etiology. While arterial aneurysms generally have a fusiform or saccular form and can exert pressure on surrounding tissues, aneurysms at the spinoglenoid notch are extemely rare, and it is therefore unlikely that an aneurysm led to the observed pressure erosion (Thomas and Ammar, 2000; Zarid et al., 2009).

4.3. Venous varix

A venous varix is an abnormally distended vein that typically has a tortuous course. Most commonly arising in the lower extremity, varices can arise due to trauma, thrombosis, or systemic factors, and can compress adjacent structures. With imaging, venous varices in the spinoglenoid notch have appeared as fusiform structures, 6–10 mm in diameter (Carroll et al., 2003). In the present case, a tubular form would differ from the mass that created the localized circular depression, making a venous varix an unlikely option.

4.4. Tumor

Various malignant and benign tumors may arise in soft tissue. In general, malignant masses tend to be larger, irregular, heterogenous, and faster growing, and they often demonstrate an outgrowth of their vascular supply (Aga et al., 2011). Further, malignant tumors may lead to bone erosion, cortical destruction, and periosteal reaction. Given their general characteristics, it is not likely that a malignant tumor produced the smooth-sided, regular depression. Further, they are relatively uncommon.

Compared to malignant forms, benign soft tissue tumors are more common and tend to be slower growing, smaller sized, more homogenous, with well-defined margins, and a tendency to displace rather than invade other structures (Aga et al., 2011). Of the various benign soft tissue tumors, a lipoma is the most likely candidate to consider for the observed circular depression. Lipomas are slow-growing, lobulated fatty masses that are enclosed within a thin capsule, and may be found in subcutaneous tissue or in deeper locations, including within or between muscles. With imaging, they appear as well-circumscribed ovoid masses (Wu and Hochman, 2009). Lipomas however, typically do not extend toward joints, leaving the flattened area between the concavity and the glenoid rim unexplained.

4.5. Cyst

Clinically, masses identified on MRI at the spinoglenoid notch have most commonly been cysts (e.g., Fritz et al., 1992). The basic definition of a cyst is a fluid- or gas-filled sack. Usually benign, they may be intraosseous, subperiosteal, or extraosseous. Since the regularity of the cortex in the present case argues against an intraosseous or subperiosteal lesion, the discussion will focus on extraosseous cysts.

The majority of extraosseous cysts that arise in the shoulder can be categorized histologically as synovial or ganglionic. The two are very similar in their appearance, composition, and proximity to joints, but synovial cysts are lined with synovial cells (Neto and Nunnes, 2016). Because of their similarities, distinguishing between a synovial and ganglion cyst is frequently impossible with imaging, and cannot be determined until the mass is aspirated and analyzed (Neto and Nunnes, 2016; Blankenbaker and Davis, 2016). As a consequence, in the clinical literature, cystic lesions in the spinoglenoid notch have been variably described as ganglion cysts, ganglia, synovial cysts, glenoid labral cysts, spinoglenoid cysts, periglenoid ganglion cysts, and paralabral cysts (Blankenbaker and Davis, 2016; Neto and Nunnes, 2016; Tirman et al., 1994). Paralabral cyst is frequently used in imaging studies to describe anatomic features rather than histologic appearance, and that is the term we will use here.

The term "paralabral" indicates that the cyst is located in proximity to the glenoid labrum. The glenoid labrum is a fibrocartilaginous ring that surrounds the glenoid cavity, acts to slightly deepen the articular surface, and anchors the GHJ capsule. Paralabral cysts are commonly found medial to the posterior glenoid labrum, at the spinoglenoid notch (Neto and Nunnes, 2016).

Although the exact mechanism of paralabral cyst formation is not clear, the leading hypothesis is that a tear or avulsion of the labrum acts as a one-way valve, permitting joint fluid to expand out of the joint cavity and into the paralabral tissues, following a path of least resistance (Tirman et al., 1994; Moore et al., 1997). Exudate from tears of the posterior-superior glenoid labrum typically expands between the supraspinatus and infraspinatus muscles toward the spinoglenoid notch (Tirman et al., 1994; Moore et al., 1997). The fluid, unable to return to the joint, continues to exude, enabling the continued existence of the cyst (Piatt et al., 2002). This suggested mechanism is supported by the fact that a high prevalence of paralabral cysts are associated with labral tears, and by the fact that a neck or stalk of the cyst is often seen at a location corresponding to the tear (Neto and Nunnes, 2016; Kim et al., 2012; Schroder et al., 2008; Piatt et al., 2002; Tung et al., 2000; Fehrman et al., 1995; Tirman et al., 1994). It is through the stalk that the cyst maintains communication with the joint cavity and receives fluid.

On imaging, paralabral cysts are well-defined and smoothly marginated homogenous masses, and they may be round- or oval-shaped, unilocular or multilocular (Cummins et al., 2000; Tung et al., 2000). Cyst size is variable, ranging from 3 to 70 mm in diameter, with an average of 23 mm (Tirman et al., 1994; Moore et al., 1997; Tung et al., 2000; Schroder et al., 2008; Kim et al., 2012). While unilocular cysts tend to be smaller than multilocular forms, cyst size may progressively increase over time (Blankenbaker and Davis, 2016).

Paralabral cysts are occasionally associated with pressure erosion, which is indicative of the slow-growing, chronic nature of the mass (Blankenbaker and Davis, 2016; Schroder et al., 2008). Tirman et al. (1994:655) reported that 3/20 patients (15%) in their series showed erosive bone changes in the posterior scapula subjacent to a paralabral cyst, and noted that while a portion of the cyst sat in a resulting depression, the majority was found external to it.

In the present case, the observed pathology is consistent with what is clinically described for a paralabral cyst: 1) the regularity of the cortex of the defect suggests an extraosseous lesion, 2) the circular depression reflects pressure erosion from a slow-growing, chronic mass, 3) the narrow depression extending between the circular depression and the glenoid indicates that the mass communicated with the joint cavity via a stalk, 4) the location of the stalk at the posterior-superior glenoid rim and the mass at the spinoglenoid notch is typical for a cyst that resulted from a posterior-superior labral tear.

5. Discussion

In addition to causing pressure erosion, paralabral cysts can also compress underlying neurovasculature. At the spinoglenoid notch, the suprascapular nerve and vessels are at risk for entrapment, as they pass from the supraspinous fossa through the spinoglenoid notch to the infraspinous fossa (Fig. 4).

The suprascapular nerve is a mixed motor and sensory nerve that courses with the suprascapular vessels. In the supraspinous fossa, the neurovascular bundle supplies branches to supraspinatus and receives sensory branches from the posterior GHJ capsule. In the infraspinous fossa, the nerve supplies motor branches to infraspinatus and the

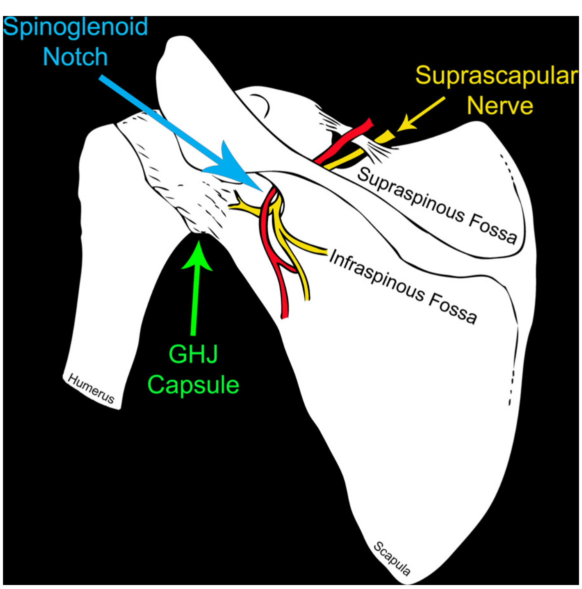

Fig. 4. Schematic of the posterior left scapula and proximal humerus, showing the path of the suprascapular nerve.

Fig. 5. Atrophy of the left infraspinatus, secondary to a paralabral cyst at the spinoglenoid notch.
Reprinted by permission from Springer Nature: Springer, Knee Surgery, Sports Traumatology, Arthroscopy. Compression of the suprascapular nerve by a ganglion cyst of the spinoglenoid notch: the arthroscopic solution. Sven Lichtenberg, Petra Magosch, Peter Habermeyer. © Springer-Verlag 2004. https://www.springer.com/medicine/orthopedics/journal/167.

accompanying vasculature supplies the musculature of the fossa (Moore et al., 2015).

Cadaveric studies found that the suprascapular nerve passes through the spinoglenoid notch within 10 mm from the base of the scapular spine and approximately 18 mm from the posterior glenoid rim (range: 14–25 mm) (Bigliani et al., 1990; Warner et al., 1992). Because of the narrow passage, even small cysts (0.5–10 mm) have been found to cause entrapment (Bigliani et al., 1990; Fritz et al., 1992; Moore et al., 1997; Schroder et al., 2008).

A paralabral cyst that develops at the spinoglenoid notch can compress the portion of the suprascapular nerve that supplies motor branches to infraspinatus (Ferretti et al., 1998). Since this muscle contributes to the external rotation and stability of the GHJ, both will be weakened. Eventually, infraspinatus may atrophy, leaving a visible depression on the individual's posterior shoulder (Fig. 5) (Skirving et al., 1994; Lichtenberg et al., 2004). Although the suprascapular artery may also be compressed by the mass, the blood supply will likely be sustained due to sufficient collateral circulation (Moore et al., 2015).

5.1. Clinical presentation

As noted, in most patients a paralabral cyst is a secondary sign of a labral tear (Tirman et al., 1994). Such tears can result from acute trauma such as a direct blow to the shoulder or falling onto an outstretched arm, or develop from chronic repetitive stress associated with manual work or strenuous sports, such as lifting weights or overhead activities (Fritz et al., 1992; Tirman et al., 1994; Fehrman et al., 1995; Tung et al., 2000; Piatt et al., 2002; Schroder et al., 2008; Kim et al., 2012; Radic and Wallace, 2015). Some patients however, report no history of trauma or stress.

It is possible that a paralabral cyst may resolve by itself through either spontaneous decompression or rupture, but the number of reported incidences is low (e.g., 3–10%) (Fritz et al., 1992; Piatt et al., 2002). Although patients may be asymptomatic, the chief complaint of symptomatic patients is shoulder pain and weakness in external rotation of the GHJ (Fehrman et al., 1995; Tung et al., 2000; Piatt et al., 2002). In spite of symptoms, patients are able to function fairly well, given that teres minor and deltoid are able to accomplish the same action as infraspinatus.

5.2. Paleopathology

To our knowledge, paralabral cysts at the spinoglenoid notch have not previously been reported in the paleopathological literature. Mays (2005, 2009; in Booth, 2014) however, reported several observations of cystic cavities in the subchondral bone of shoulder and hip joints that may also be associated with labral tears. One investigation examined supra-acetabular cysts among a medieval skeletal sample from North Yorkshire, England (Mays, 2005), another described cystic cavities in the posterior-superior margin of the glenoid fossa of a young adult male from late medieval England (Mays, 2009), and another case described cystic cavities in both the glenoid fossa and the acetabulum of a middle adult male from a late Roman burial at Dorchester on Thames, Oxfordshire, England (Booth, 2014:254-260). In each of these cases, Mays noted the presence of a small pore on the glenoid or acetabulum that communicated with a larger cystic cavity within the subchondral bone. The cavities were well-defined, occasionally multiple, and with sclerotic margins. Because the cysts communicated with the joint surface in each case, Mays suggested that they formed following a traumatic injury that tore the labral base or articular cartilage, enabling the joint fluid to penetrate the subchondral bone.

Though similar, the present case differs from those that Mays described, in that there was no pore or cavity on the glenoid fossa that communicated with a subchondral cyst. Rather than penetrate the subchondral bone, the labral tear enabled joint fluid to herniate external to the joint capsule into the surrounding soft tissue where it remained extraosseous, with the bony sign of its presence being the circular depression.

Cysts and cyst-like lesions comprise a varied group, with diverse etiologies and characteristic features (Perdikakis and Skiadas, 2013). Since cysts result from different pathogenic pathways, it is unclear what leads to the variation seen in cysts associated with labral tears (Haller et al., 1989). Such variation may have to do with the mechanism of injury, the morphology of the joint surface, associated articular disease, or where the labral tear occurs (Haller et al., 1989). In the present case, rather than be at the base of the labrum or the articular cartilage, the tear appears to have occurred on the posterior-superior aspect, which enabled joint fluid to flow out of the joint cavity toward the spinoglenoid notch.

6. Conclusions

The circular depression observed at the spinoglenoid notch is consistent with the effects of pressure erosion from a paralabral cyst that developed secondary to a posterior-superior glenoid labral tear. A cyst at the spinoglenoid notch would likely entrap the suprascapular nerve. To our knowledge, paralabral cysts at the spinoglenoid notch have not previously been reported in the paleopathological literature. This case therefore offers a unique opportunity to examine this condition and consider how it may have affected the individual.

In the present case, it is plausible that the individual could have torn the labrum through repetitive manual labor, acute trauma due to falls or interpersonal violence, or from overhead activities. The individual likely experienced shoulder pain and weakness in the external rotation of the left GHJ, and may have demonstrated visible atrophy of infraspinatus. Nevertheless, the individual would have functioned well, given that other muscles are able to accomplish the same action as infraspinatus.

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