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ORIGINAL ARTICLE • SHOULDER - RADIOLOGY

Digital tomography is an effective investigation for sternoclavicular joint pathology

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Abstract

Objective Plain radiographs of the sternoclavicular joint (SCJ) are difficult to interpret, and a CT or MRI scan is the usual investigation of choice. At our hospital, we use digital SCJ tomograms as our first-line investigation for all SCJ pathologies. We wanted to ascertain whether this is a safe and appropriate first-line imaging investigation.

Materials and methods We retrospectively reviewed every patient who had undergone an SCJ digital tomogram (DT) over a 4-year period. We cross-referenced each patient with their records to assess the reason for referral, result, requirement for further investigation, diagnosis and management.

Results We identified 132 SCJ tomograms over the study period. Twelve patients were referred from other hospitals with pre-existing imaging and were excluded. The reasons for radiological investigation in the remaining 120 patients were pain/lump without trauma (54.2%), pain/lump with trauma (30.8%) and post-operative review (15%). Of the 102 patients who had DT as their initial investigation, the most common diagnoses identified included osteoarthritis, normal SCJ, fracture and dislocation among others. Only 18 (17.6%) of these patients required further investigation with CT and/or MRI.

Conclusion Our study is the first to assess digital tomography in SCJ pathology. We have shown that digital tomograms are an accurate and economically beneficial investigation for SCJ pathology and propose that it should be used as a first-line imaging investigation.

Keywords Sternoclavicular joint · Digital tomography · SCJ pathology · SCJ imaging

Introduction

The sternoclavicular joint (SCJ) is a pivotal articulation in the upper limb girdle, acting as an important fulcrum for movement of the shoulder. Movement at the glenohumeral joint causes rotational and translational strain in the clavicle which is transmitted to the sternoclavicular joint [1]. In recent years, there has been an increasing interest in conditions at the SCJ, particularly osteoarthritis, medial clavicle fractures and SCJ dislocations [2–4].

Although standard anteroposterior radiographs are often used as initial imaging, they are difficult to interpret due to overlapping vertebrae and ribs. The serendipity view has been described by Wirth and Rockwood [5], where the X-ray beam is titled 40° in the cephalad-oblique direction and can be used to help diagnose SCJ dislocations and osteoarthritis [6]. Static images have largely been superseded by computerised tomography (CT) and magnetic resonance imaging (MRI) due to higher sensitivity [7]. However, these studies are time-consuming, more costly and in the case of CT, produce increased radiation exposure for the patient. Furthermore these tests can be difficult to obtain due to scheduling and capacity issues and often necessitate a further clinic appointment at a later date.

Digital tomography (DT) uses a single pass of the radiographic generator over a digital detector, obtains a sequence of multiple digital X-ray images (12–60) and is performed quickly in the X-ray department. To our knowledge, there has been no published literature on digital tomography in diagnosing sternoclavicular pathology. We have been using digital tomograms as a first-line investigation of sternoclavicular pathology over the last 5 years and present our findings with an aim of validating digital tomography as

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a safe, accurate and appropriate imaging modality for SCJ disorders.

Materials and methods

From our hospital's central imaging system, we retrospectively reviewed all patients who have had sternoclavicular joint digital tomograms over a 4-year period. We then cross-referenced each patient with our computerised records looking at their history, reason for referral and for requesting an SCJ investigation, the radiological result, requirement for any further investigation, their diagnosis and subsequent management.

Patients with an SCJ problem who had been referred as a tertiary referral from another hospital and who had already had radiological investigations were excluded. We obtained and reviewed all the SCJ radiological images (Figs 1, 2, 3). They had all been previously reported by a consultant radiologist, and those investigations requested by the orthopaedic department were all reported by a specialist, musculoskeletal consultant radiologist.

Imaging technique

Digital tomography was performed using a GE Discovery XR650 digital X-ray machine with auto-positioning. The images were taken over 10.5 s with a radiation exposure time of 0.2 ms. The X-ray camera gantry travels through a set angle from 23.7° above to 23.7° below the horizontal taking 40 images. The images are displayed on a computer screen, in the same way as CT and MRI scans, and can be scrolled through manually or in a cine sequence.

Results

A total of 132 digital SCJ tomograms were performed over this study period. Twelve of these had been referred from another hospital and had other imaging, e.g. CT/MRI. These were excluded from further evaluation.

From the remaining 120 patients, we grouped indications for investigation as pain/lump without trauma, pain/lump with trauma and post-operative as shown in Table 1. The diagnoses obtained are shown in Table 2. Of the three patients with an unknown diagnosis, subsequent imaging confirmed infection (1) and osteitis (2). No complications directly related to the use of digital tomography were observed in our patient cohort.

In 18 cases, further imaging was required, e.g. CT/CT angiogram/MRI as shown in Table 3. The main reason for CT imaging was for pre-operative planning with dislocations, large posterior osteophytes and very medial clavicular fractures. In patients with posterior dislocations, we ordered CT angiograms. The main reason to organise MRI was to assess the soft tissue structures, usually in the context of investigating a potential acute disc tear in younger patients with ongoing pain and a normal tomogram. We also used MRI scans to assess for graft incorporation following stabilisation and to rule out inflammatory arthritis or infection.

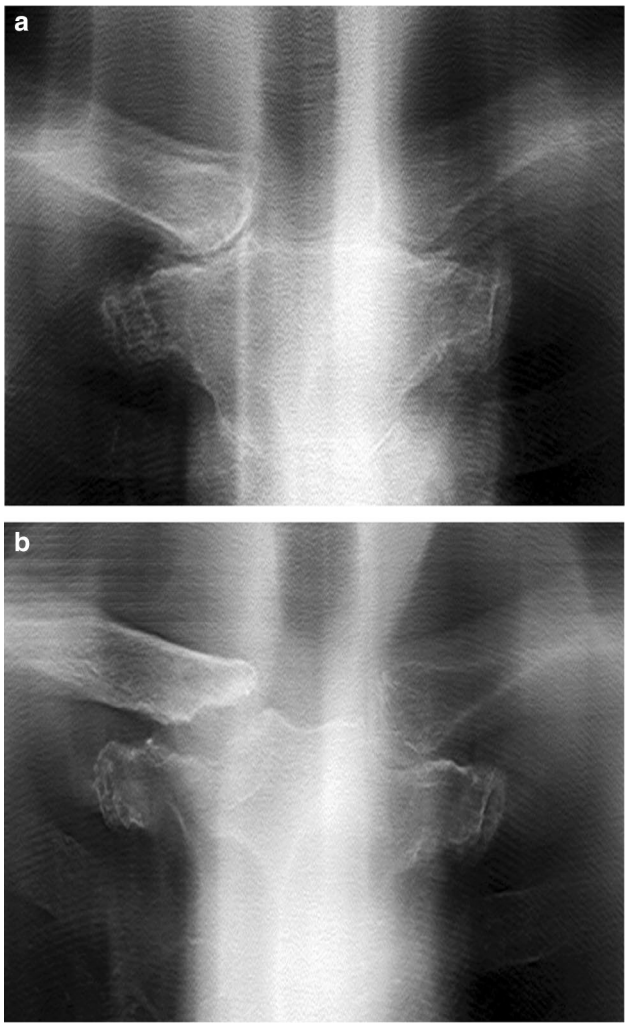

Fig. 1 **a** Conventional digital SCJ tomogram demonstrating osteoarthritis in the right SCJ. The changes are predominantly on the clavicular side. **b** Conventional digital SCJ tomogram of the same patient after arthroscopic SCJ excision. The articular inferior two-thirds have been excised

Discussion

The challenge of accurately diagnosing SCJ pathology is well described, particularly using plain radiographs. In recent years, there has been an increased interest in treating

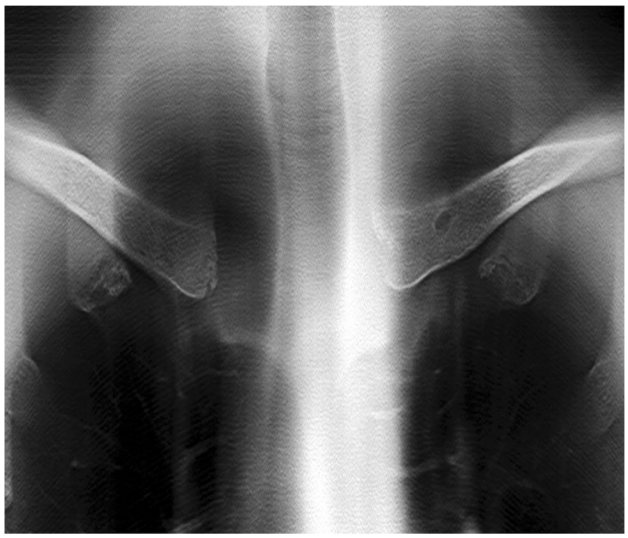

Fig. 2 Conventional digital SCJ tomogram demonstrating anterior dislocation of the left SCJ in a 20-year-old male. Note that it appears larger

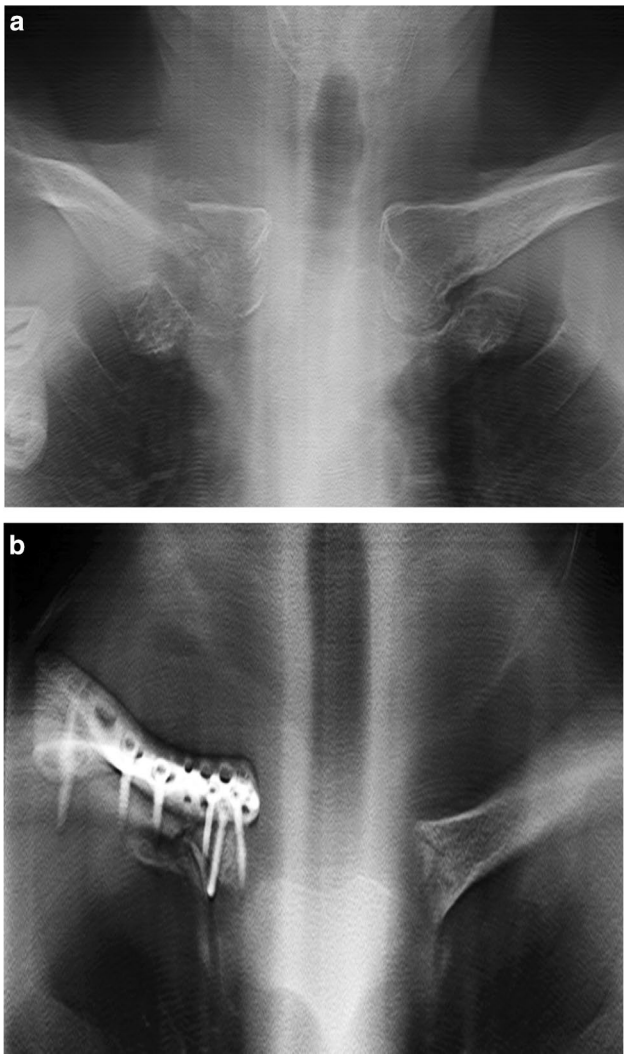

Fig. 3 **a** Conventional digital SCJ tomogram demonstrating a displaced comminuted intra-articular fracture of the medial end of the clavicle/SCJ. **b** Conventional digital SCJ tomogram of the same patient following open reduction and internal fixation with a contoured locking clavicle plate. (Note the accurate assessment of the screw positioning within the comminuted medial end of the clavicle)

sternoclavicular joint pathology which has partly been aided by better imaging techniques.

The first description of the use of conventional tomography in clinical practice was in 1953 with the first study to specifically assess the SCJ being in 1985 [8, 9]. The last published study on conventional tomograms of the SCJ was in 1996. During this, Jurik et al. [10] compared eight-plate tomogram series with spiral CT scans and found lower efficacy and similar radiation doses between the two groups. This paved the way for CT (and MRI) to be the primary imaging modalities of choice in every published subsequent study and in clinical practice.

In recent years, advances in digital X-ray machines have evolved traditional tomograms to digital tomograms. The improvements include auto-positioning and reduced radiation dose (0.5 millisievert (msV) for DT, 6.0 msV for standard tomograms and 6.6 mSV for CT) [11, 12] while being able to capture images quickly (10 s). DT also allows the use of standard X-ray equipment without the radiographers requiring further training. Furthermore, DT enables us to make a diagnosis in clinic immediately in the majority of patients and therefore does not necessitate a post-imaging follow-up appointment. Digital tomography is also financially beneficial. The cost, as supplied by our institution, for a plain X-ray is £90, digital tomogram is £110, CT scan is £500 and MRI scan is £620.

In our study, of the 102 patients who had an SCJ tomogram as their initial investigation, only 18 (17.6%) required further imaging. This is in contrast to other studies, where the primary imaging is CT or MRI [1, 13]. Of particular significance was our use of digital tomograms in osteoarthritis of the sternoclavicular joint. We were able to diagnose and exclude 48 and 39 patients, respectively, with only four requiring further imaging (CT) for pre-operative planning.

Table 1 Indication for requesting SCJ digital tomograms

Indication	Pain/lump without trauma	Pain/lump with trauma	Post-op
No. patients (120)	65	37	18
Percentage (%)	54.2	30.8	15

Digital tomography was useful in other suspected diagnoses too, for example, in suspected SCJ dislocations due to swelling. However, the presence of a swelling at the SCJ

Table 2 Radiological diagnoses made from digital tomogram

Diagnosis	Number (102)	Percentage (%)	Figure no.
Osteoarthritis	48	47.1	Figure 1
Normal	39	38.2	
(Post-operative)	(18)		Figure 1
Trauma			
Dislocation	5	4.9	Figure 2
Fracture	4	3.9	Figure 3
Subluxation	2	2	
Old fracture	1	1	
Unknown diagnosis	3	2.9	

Post-operative tomograms were not included in the analysis as they offered no diagnostic aid

Table 3 Indications for further imaging

Indication	Imaging modality	Number
Suspected acute disc tear	MRI	7
Pre-operative planning	CT	4
Posterior dislocation	CT angiogram	2
Inflammatory arthritis/infection	MRI	5

does not always indicate the presence of a dislocation and is unlikely in the absence of trauma. Van Tongel et al. [14] found that degenerative sternoclavicular joints were not only 4.2 mm wider but also 8.4 mm anterior compared with the contralateral unaffected side.

While digital tomograms provide adequate information to reach a diagnosis in the majority of patients, they only provide images in a single plane, and give no information on the posterior vascular structures or surrounding soft tissues. The advantages of CT/MRI remain and are still required in certain cases. As CT scans are usually presented in three planes and can be reformatted, they can provide very accurate 3D images which can be useful in pre-operative planning. Furthermore, CT arteriograms can demonstrate the vascular structures posterior to the mediastinum, the proximity of the medial end of a displaced clavicle and any evidence of vascular injury.

An MRI scan has benefits of assessing the soft tissues, including the intra-articular disc, surrounding capsulo-ligamentous structures and the posterior mediastinal structures [15, 16]. Additionally, they may be diagnostic in medial clavicular physeal injuries, inflammatory arthropathies and infection.

There has been little published on digital tomography in recent years. Recently, Barcia et al. found MRI to be superior at diagnosing occult scaphoid fractures compared with DT (100% vs. 67% sensitivity) in six cases [17]. However, the high sensitivity of MRI was offset by two cases where MRI indicated a fracture which was not corroborated by follow-up imaging or clinical examination. They concluded that DT is comparable to other imaging modalities with the previously described benefits. Other authors have also found DT to be useful to assess union, delayed union or non-union in scaphoid fractures [18]. Our study is the first to assess digital tomography in sternoclavicular joint pathology and adds to the growing body of evidence of its efficacy and benefits.

The limitations of this study lie in the retrospective design which can lead to bias in data collection and interpretation. Furthermore, there is a lack of documented long-term follow-up to assess outcomes; however, this is beyond the remit of this paper. In future, multicentre studies incorporating large numbers of patients with a varying range of pathologies would be useful to further determine the role of digital tomography in orthopaedic practice.

Despite the limited evidence in this field, we believe our study is sufficient to initiate a change in future practice to incorporate DT into the arsenal of radiological investigations for SCJ pathology. Digital tomography should be considered as a first-line investigation modality given the benefits of reduced radiation dose and cost.

Conclusion

Osteoarthritis, subluxations, dislocations and fractures account for nearly all of the conditions that present around the SCJ. While a plain X-ray is not sufficient to consistently diagnose and monitor the treatment of these conditions, the results of this study suggest that an SCJ tomogram is sufficient in the majority of cases. We have shown that digital tomograms are a safe, accurate and economically beneficial investigation for SCJ pathology. This test usually negates the need for CT or MRI and their associated risks of increased radiation (CT) and further clinic follow-up appointments. We propose that a digital tomogram should be used as an initial screening investigation for sternoclavicular joint pathology.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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