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Heterogeneous MR arthrography findings in patients with subacromial impingement syndrome – Diagnostic subgroups?

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ABSTRACT

Background: Subacromial Impingement Syndrome (SIS) is frequently diagnosed, but treatment results vary greatly. It is increasingly reported that SIS symptoms are caused by various underlying mechanisms that need distinctive treatment strategies. We evaluated a set of specific MRI Arthrography (MRA) characteristics that have been related with underlying mechanisms for SIS in the literature, in patients with SIS.

Methods: In 47 patients diagnosed with SIS, MRA characteristics were evaluated and categorized into categories of potential underlying mechanisms: (1) extrinsic: e.g. acromion shape; (2) intrinsic: e.g. tendinosis; (3) dynamic: e.g. signs of glenohumeral (micro-)instability. Control values were obtained from the literature. With cluster analysis, potential patient subgroups were assessed.

Results: In 17 (36.2%) patients originally diagnosed with SIS, specific other conditions were found, including rotator cuff tears and labrum lesions. In the remaining 30, all had positive signs of at least one of the predefined underlying mechanisms. Patients could be categorized into 2 groups: predominantly findings corresponding with extrinsic/structural causes, or with dynamic/(micro)instability.

Conclusions: MRA characteristics in patients with SIS symptoms are heterogeneous and many patients have specific other shoulder conditions causing symptoms. Patients without specific other conditions have MRA characteristics associated with either extrinsic (structural), or dynamic (e.g. micro-instability) underlying mechanisms.

1. Introduction

Subacromial Impingement Syndrome (SIS) is diagnosed in 44–65% of the patients with shoulder complaints in primary health care (Michener et al., 2003). SIS is generally defined as irritation of the soft tissues in the limited subacromial space, leading to pain with abduction, decreased active range of motion and loss of arm force (Bigliani and Levine, 1997; Codman, 1934; Koester et al., 2005). Opinions concerning its etiology, diagnostic criteria, corresponding radiographic characteristics, and treatment strategies vary greatly (Bamji et al., 1996; Bright et al., 1997; Dorrestijn et al., 2007, 2009; Johansson et al., 2002; Kelly et al., 2010; Lewis, 2009; Michener et al., 2003; Smidt and Green, 2003; van der Windt et al., 1998). Nevertheless, there are many publications on patients with the diagnostic label "SIS". Conflicting definitions of SIS are used across these studies, complicating interpretation of reported results (Green et al., 1998). More insight in underlying causes and identification of potential etiologic or diagnostic patient subgroups is needed in order to improve diagnostic criteria and treatment outcome of SIS symptoms. We investigated specific Magnetic Resonance Imaging (MRI) features related with SIS and subacromial narrowing in the literature, in patients clinically diagnosed with SIS, and we assessed whether patient subgroups can be identified using a comprehensive combination of MRI arthrography features. Gathered information might serve as a foundation for future studies upon which clinical decision making and development of tailored treatment strategies can be based.

"Impingement syndrome" was introduced in 1972 by Dr. Neer as a combination of typical clinical findings with various underlying mechanisms and stages (Neer, 1972). Over the years, this evolved to the "*subacromial* impingement syndrome", which (wrongfully) suggests high specificity and anatomic differentiation

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of this entity. Since 1972, many diagnostic tools have been developed, including ultrasound, MRI and MR arthrography (MRA), that can more accurately differentiate between causes of shoulder symptoms (Bureau et al., 2006; Papadonikolakis et al., 2011; Read and Perko, 1998). Consequently, "SIS" has become increasingly controversial as a "diagnosis". Some consider SIS symptoms as a consequence of several possible underlying mechanisms and pathologies rather than a specific diagnosis (McFarland et al., 2006). Furthermore, several conditions can cause SIS symptoms and can be (mistakenly) diagnosed as SIS; in a recent study at our institution 17.5% of patients selected for a SIS trial by experienced shoulder surgeons had to be excluded after MRI evaluation because of specific other shoulder conditions (Henkus et al., 2009).

Various studies have reported on specific pathologic MRI or MRA findings in patients with impingement symptoms. Characteristics for *extrinsic* underlying mechanisms (structural or anatomic causes) include a hooked acromion (Epstein et al., 1993), acromioclavicular (AC) joint osteoarthritis with caudal osteophytes (de Abreu et al., 2005; Oh et al., 2010; Roidis et al., 2009; Strobel et al., 2003), or subcoracoid impingement (narrowed space between coracoid and humerus) (Bonnet and Walsh, 2005; Giaroli et al., 2006; Lo and Burkhart, 2003; Mulyadi et al., 2009). Also signs of *intrinsic* pathologies can be found, including tendinosis, partial rotator cuff (RC) tears and bursitis (Cholewinski et al., 2008; Giaroli et al., 2005; Milgrom et al., 2012; Schaeffeler et al., 2011; Seeger et al., 1988; White et al., 2006), either as a cause of SIS symptoms, or consequent to other underlying mechanisms. Lastly, SIS symptoms can be related with humerus cranialisation and *dynamic* compression of the subacromial tissues during arm-shoulder motion, as a result of e.g. glenohumeral (micro)instability, with specific associated findings on MRI (Belling Sorensen and Jorgensen, 2000; de Witte et al., 2011; Jobe et al., 1989; Provencher et al., 2008).

The primary goal of the current study was to investigate a group of patients with the clinical diagnosis SIS with MRA and a broad set of specific measurements, in order to evaluate characteristics of the various reported underlying mechanisms associated with SIS symptoms. Additionally, we aimed to identify different phenotypes of SIS symptoms, i.e. diagnostic subgroups, using the comprehensive set of MRA characteristics.

2. Materials and methods

2.1. Selection of participants

Patients with impingement symptoms were recruited by 3 experienced orthopedic shoulder surgeons from Leiden University Medical Center (LUMC), the Hague Medical Center (MCH) and Rijnland Hospital, Leiderdorp, in an ongoing prospective multicenter observational cohort study on SIS. Data collecting included kinematic, clinical and radiographic methods (de Witte et al., 2011). In the current study, MRA characteristics of all consecutive patients included from April 2010 until December 2012 are reported and compared with control values from the literature.

Patients were enrolled after clinical examination and shoulder radiographs (anteroposterior in external and internal rotation and axial views) at the outpatient clinic. Inclusion criteria were a painful arc, a positive Neer impingement test with lidocaine, a positive Hawkins test, diffuse lateral shoulder pain for >3 months, and one or more of the following criteria: night pain or incapable of lying on the shoulder, scapulohumeral dysrhythmia, pain with retroflexion and/or internal rotation (e.g. putting on a jacket, overhead activities), positive Yocum test. Exclusion criteria were: age <35 or >60, clinical signs of adhesive capsulitis (including less than 90° of passive external rotation in 90° of abduction), history of fracture or dislocation of the shoulder, history of surgery around the shoulder, known co-morbidities on the affected shoulder (including benign or malignant tumours), Hill Sachs lesion, glenohumeral or symptomatic AC joint osteoarthritis (positive AC compression test and/or pain with palpation of the AC joint), rheumatic disorder, calcific tendonitis >3 mm on radiographs or cervical radiculopathy or other neurological deficits.

The medical ethics committees of the participating hospitals agreed to all stages of the study. Eligible patients who were willing to participate in the entire SIS project and who signed informed consent underwent a study-specific MRA of the shoulder and kinematic evaluation in our laboratory for kinematics and neuromechanics (LK&N). Patients had standard treatment by their referring clinician outside of the scope of this study.

2.2. MR arthrography

MRA extends the capabilities of conventional MRI because contrast solution distends the joint capsule, outlines intra-articular structures, and leaks into abnormalities like tendon tears (Steinbach et al., 2002). We used fluoroscopic guidance for intra-articular contrast administration with a 20–22 Gauge needle. After correct needle positioning, checked with 1–2 cc of nonionic iodinated contrast (Ultravist 300, Bayer) a maximum of 15 cc of diluted Gadolinium DTPA (0.4 cc:100 cc 0.9% NaCl) was administered.

Standardized MR imaging was performed 30 min after contrast administration on a 1.5 T unit (Avanto Siemens, Erlangen, Germany, or Philips Intera, Best, The Netherlands) with a dedicated shoulder coil and the arm in neutral position (with slight internal rotation). The following sequences were used: axial, coronal oblique, sagittal oblique, T1-weighted fast spin-echo with fat suppression and coronal oblique T2-weighted with fat suppression. The field of view was 16–18 cm, slice thickness 3 mm or 4 mm with 1 mm gaps.

2.3. MR arthrography assessment

The MRA images were evaluated by an experienced musculoskeletal radiologist at the LUMC, unfamiliar with the underlying hypotheses of this study, using PACS IDS5 11.4 software (Sectra Medical Systems AB, Linköping, Sweden). With a standardized MRA check-list, specific other conditions that can cause SIS symptoms were evaluated in all patients, including SLAP (Superior Labrum Anterior–Posterior) lesion, os acromiale, lesion of the Biceps pulley, Hill Sachs lesion, Biceps tendon tear or (sub)luxation, glenohumeral ligament pathology (i.e. tears of the inferior (IGHL), middle (MGHL), or superior (SGHL) glenohumeral ligament), or full-thickness RC tendon tear.

Patients with SIS symptoms without signs of other specific shoulder conditions were assessed for the presence of MRA characteristics typically associated with several phenotypes, or potential underlying mechanisms for SIS symptoms in the literature. To define pathologic observations, cut-off values for MRA measurements were obtained from the literature, or based on 95%-confidence intervals (95%-CI) of measurements in healthy shoulders in the literature. Where applicable, Taylor expansions were applied to calculate 95%-CI's of continuous data in the literature, using reported means and standard deviations.

MRA characteristics were categorized into three phenotypes for SIS, using a theoretical framework for potential underlying mechanisms of SIS, as derived from our previous study in which we reported that SIS, i.e. "a misbalance between subacromial volume and the space needed for subacromial structures" can be caused by: (de Witte et al., 2011)