

# Descriptive analysis of the musculoskeletal case load referred for ultrasound imaging in an Auckland imaging practice: A case study

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## ABSTRACT:

*Background:* Musculoskeletal ultrasound (MSK US) imaging provides visualisation of a large number of superficial anatomical structures including nerves, joints, ligaments, tendons and muscles. The utility of ultrasound has been compared to other common imaging techniques such as Magnetic Resonance Imaging (MRI,) and is proving to be of similar, or better accuracy, for some applications. In New Zealand, ultrasound is a secondary level service, requiring referral from a primary practitioner. Included in primary health services are musculoskeletal practitioners (physiotherapists, osteopaths, podiatrists and chiropractors). These professions often rely on palpation and physical examination to inform diagnostic reasoning. However, there are limitations related to accuracy of this approach. Diagnostic ultrasound is a tool that can be used to inform clinical practice by aiding diagnosis of musculoskeletal conditions. To date, there appears to be just one study investigating referral protocols for musculoskeletal ultrasound.

*Aim:* The aim was to identify the descriptive characteristics of cases referred to one sonographer, working within a private MSK US practice located within an osteopathy tertiary teaching clinic in Auckland, New Zealand.

*Methods:* A retrospective stratified random sample of 1000 cases was sampled from the total number of available records from one practice between 1 January 2016 and 31 December 2016. Two sources of information were available for each case: a single referral request (paper-based referral request), and the associated sonography imaging report (radiologist endorsed sonography report letter). Information extracted from these sources included patient demographic characteristics, referrer characteristics, descriptive referral request, and imaging report information. Systematized Nomenclature of Medicine – Clinical Terms coding was used to code referrer queries and sonographer’s diagnostic opinions.

*Results:* The most common body regions referred for scanning were shoulder (27%) followed by knee (16%) and ankle (15%). Clinical indications for sonography requests were investigated, referrers wrote a maximum of 5 clinical indications per referral. Clinical indications generally included ‘location of pain’, ‘mechanism of injury’, ‘positive orthopaedic tests’, and ‘history of injury’. Only 27% of referrals provided a time since injury while the majority included other specific information such as clinical signs (e.g. ‘positive orthopaedic tests’). Overall, 35% of referrals did not include a query (median number of queries per referral was 1 (IQR=2)). Excluding those who did not include a clinical query with their request (35%), those who gave a smaller number of queries generally had a higher level of agreement between their queries and the sonographer’s opinion.

*Conclusion:* This project explored the characteristics of referral requests and sonography report. Further research is needed to explore the utility of referral for diagnostic ultrasound by musculoskeletal practitioners, and to determine whether referral protocols should be developed to increase efficacy of the referral process.

*Keywords:* musculoskeletal, sonography, diagnostic ultrasound, diagnosis, referral, physiotherapy, osteopathy, sports medicine

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# List of Abbreviations

ACC – Accident Compensation Corporation

CAF – Calf/ankle/foot regions

CAM – Complementary and Alternative Medicine

CI – Clinical Indication

DHB – District Health Board

DUSI – Diagnostic Ultrasound Imaging

HPCA – Health Practitioners Competency Assurance Act

IQR – Interquartile range

Mdn – Median

MOH – Ministry of Health

MOI – Method of Injury

MRI – Magnetic Resonance Imaging

MSK US – Musculoskeletal Ultrasound

NZ – New Zealand

OCNZ – Osteopathic Council of New Zealand

RUSI – Rehabilitative Ultrasound Imaging

USI – Ultrasound Imaging

# CHAPTER 1 THESIS INTRODUCTION

Ultrasound imaging (USI) is a form of non-ionising radiological diagnostic imaging. It is a non-invasive imaging technique that provides real-time assessment. In the musculoskeletal (MSK) context, USI provides insight into a large number of superficial anatomical structures such as nerves, joints, ligaments, tendons and muscles (Henderson, Walker, & Young, 2015a). The utility of USI has been compared to other common imaging techniques such as Magnetic Resonance Imaging (MRI) and is proving to be of similar, or better accuracy, when examining certain soft tissue structures such as rotator cuff tears or plica injuries in the knee (Henderson, Walker, & Young, 2015b; Kang, Horton, Emery, & Wakefield, 2013).

Ultrasound imaging, as with all diagnostic imaging in New Zealand (NZ), is considered a secondary service within the NZ healthcare system. For a patient to receive a secondary service they must be referred from their first point of contact – a primary healthcare practitioner. In NZ, referrals for musculoskeletal ultrasound (MSK US) can originate from primary healthcare practitioners providing MSK care including physiotherapists, chiropractors, podiatrists and osteopaths (these constitute MSK practitioners<sup>1</sup>).

Musculoskeletal practitioners often rely on manual palpation and physical examination to inform their diagnostic reasoning. However, there are well known limitations of the level of accuracy of palpation (Kilby, Heneghan, & Maybury, 2012). In response to both acknowledgement of these limitations, and the increased access and availability of ultrasound imaging, there is increasing interest in the role and clinical utility of MSK US in diagnosis of musculoskeletal conditions.

The basic principle underpinning ultrasound imaging is sending high frequency sound waves from a transducer into the body. Each tissue type has a unique composition which corresponds to the rate, strength and angle of reflection of the sound waves. This is converted into an image via the transducer and imaging unit to create a real-time image of the underlying soft tissues (Bates, 1996; J. L. Whittaker & Stokes, 2011). The quality of MSK US images are limited by the technology available, expertise of the sonographer, depth of structure, and presence of other structures that hinder view such as bone (Bates, 1996; Cole, Twibill, Lam, Hackett, & Murrell, 2016; J. L. Whittaker & Stokes, 2011). The sonographer has the knowledge to compare the image with what might normally appear for a

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<sup>1</sup> MSK practitioner will be used in this study to represent physiotherapists, chiropractors, podiatrists and osteopaths.

given tissue, when done in conjunction with movement, tissue structure is compared with function. This can be used both diagnostically (*diagnostic* ultrasound imaging) or can be used by MSK practitioners to show the patient and test muscle contraction (*rehabilitative* ultrasound imaging) (Teyhen, 2007).

Ultrasound is an appropriate imaging modality for a variety of body regions and common injuries (Blankstein, 2011a; Henderson et al., 2015b). There are a small number of existing imaging guidelines which recommend the use of ultrasound for some of these areas. Key guidelines include ‘The diagnosis and management of knee soft tissue injuries’, ‘Referral guideline for patients presenting with shoulder pain’ and the Ottawa knee and ankle rules (Accident Compensation Corporation, 2003, 2011; Stiell, Mcknight, Greenberg, & Gh, 1994; Yao & Haque, 2012). Coincidentally, these areas (shoulder, knee and ankle) had the highest number of MSK US claims facilitated through the Accident Compensation Corporation (ACC) in 2016 and 2017 (Piuiila-Afitu, 2018b, 2018c).

The aforementioned guidelines are not specific to ultrasound. Hence, there are still many opportunities to further define or update these when comparing the range of guidelines to the researched capabilities of MSK US as a diagnostic tool. This contrasts with the situation for sonographers, who do have guidelines to follow with regards to both procedure for scanning body regions, and also for report writing (Necas, 2017; Society and College of Radiographers and British Medical Ultrasound Society, 2015). In addition, little is known about the utilisation of diagnostic MSK US by MSK practitioners, in particular, the information provided by a referrer in the referral request, and whether this information adequately informs the sonographer about the patients’ case.

To date, there have only been four key studies within Australia and NZ which have examined the physiotherapists’ use of MSK US. Three of these studies investigated potential barriers to use and the level of education MSK practitioners have received on MSK US. It was ambiguous as to whether this use by physiotherapists was for diagnostic or rehabilitative MSK US. Diagnostic ultrasound (DUSI) is, as the name suggests, used to diagnose pathologies and falls outside the scope of practice for physiotherapists in New Zealand. However, as USI has the unique ability to complete imaging whilst examining function, this also means USI can be used in a rehabilitative capacity (RUSI). That is, to act both as a visual tool for patients to simultaneously feel and see activation of deep tissues, and a measurement tool, analysing muscle function by MSK practitioners (Bates, 1996; J. Whittaker et al., 2007). Overall, these studies found that MSK US appears to be underutilised due to low training rates and lack of access (Ellis et al., 2018; Jedrzejczak & Chipchase, 2008; McKiernan, Chiarelli, & Warren-Forward, 2011). However, it is ambiguous as to whether these were for RUSI or DUSI. Roberts et al. (2006) appears to have been the first to examine the protocols physiotherapists use when

referring for diagnostic imaging. This study examined referrals for both plain film X-ray and ultrasound. Roberts et al. (2006) concluded that although there were some referral guidelines, they were not universally used by physiotherapists. As such, physiotherapists also reported a keen interest in more education on MSK US referral (Roberts, Winner, Littlejohn, Newland, & Robins, 2006).

Before prescribing education for MSK practitioners about USI it is important to understand how they refer and whether these referrals are resulting in full utilisation of MSK US as a diagnostic tool. This study will explore how MSK practitioners are referring for ultrasound, and compare what MSK practitioners include in MSK US referral to the information in the sonographer's report. The results from this study offer first insights into the referral requests of MSK practitioners and the reports of a sonographer from one practice in Auckland, NZ. Data obtained from this study outlines patient and practitioner demographics, clinical indications for the MSK US request and common queries. It elaborates on these categories with regards to the most common areas that MSK practitioners request USI for. It then compares the request to the sonographer's report and outlines the level of agreement between the MSK practitioner queries and sonographer opinion. Exploring these fields of information has provided a baseline of information that could be used in improving service delivery and referral networks between musculoskeletal practitioners and MSK US providers by acting as a platform for more specific research. Improving the efficacy of healthcare services is a key element of The New Zealand Health Strategy (2016), through its 'one team', 'smart system' approach, that is, to maximise the interaction between the health system tiers and across professions to improve efficacy of patient-centred care (Minister of Health, 2016).

## **Aim:**

The aim of this project was to identify the descriptive characteristics of cases referred to one sonographer, working within a private MSK US practice located within an osteopathy tertiary teaching clinic in Auckland, New Zealand.

## **Objectives:**

1. To describe the demographic characteristics of people referred (such as age, gender, clinical indication) for imaging.
2. To describe the referrer characteristics (including profession, geographic locality, and number of unique referrers during the 2016 year)
3. To characterise and describe the elements included in the referral request as written by the referrer (such as region of interest, time since injury and clinical indications for referral).

4. To describe the information included in the sonographer's report (such as scanning protocol and opinion<sup>2</sup>)
5. To undertake an exploratory investigation of the extent to which the clinical query of the referrer aligns with the sonographer's opinion.

This thesis first summarises the literature relevant to this project. As there are few directly related studies this is structured to explain the different elements that support MSK US as a health service. This includes explaining how MSK US fits into the NZ health system, how US equipment works, and what MSK pathologies can be diagnosed using it. This initial chapter is followed by chapters describing Methods, Results and Discussion.

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<sup>2</sup> This term was used because a diagnosis is not confirmed until the ultrasound report is endorsed by a radiologist.

# CHAPTER 2 LITERATURE REVIEW

## Literature review introduction

The aim of this literature review is intended to provide background in the technological development and use of MSK US within musculoskeletal practice<sup>3</sup> in the New Zealand healthcare environment. Information was obtained using the Unitech library bibliographic databases including Science Direct, EBSCO Host, Google Scholar (reviewing the first two pages of search results and examining articles only from 2008-2018) and Medline-PubMed. Key words such as diagnostic ultrasound, musculoskeletal ultrasound and rehabilitative ultrasound were used. Various websites for New Zealand (NZ) Government health agencies were also used to locate information documenting the structure of the NZ health system and its key strategies. A search of literature identified four relevant studies, that is, studies that have investigated the use of MSK US by manual therapists. Only one of these researched the referral protocols for ultrasound by MSK practitioners. This literature review aims to provide a general overview of diagnostic musculoskeletal ultrasound and its place within the NZ healthcare system. The structure of this review first introduces the NZ healthcare system. It then gives an overview of MSK US and potential uses for MSK practitioners. This includes an overview of body regions and structures that are commonly scanned in MSK US and the common conditions it has been shown to be useful for. The chapter then goes on to review the limited research available on this subject and how MSK US fits into the NZ health system.

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<sup>3</sup> For the purposes of this study, the term musculoskeletal practitioner encompasses physiotherapists, osteopaths, acupuncturists, podiatrists, and chiropractors.

# Healthcare in New Zealand

## The structure of healthcare in New Zealand

The NZ healthcare system is complex and involves many different professions including clinical services, support services, and those involved in management and governance such as District Health Boards (DHBs), and the Ministry of Health (MOH). One of the complexities of the healthcare system lies within its hierarchical structure. For example, in NZ there are the 20 DHBs which are responsible for planning and funding in their geographical areas. Above this DHB layer is the National Health Board, formed in 2009, to monitor the DHBs. Above this again is the MOH, which is the main advisory body of the healthcare system (Cumming et al., 2014).

The NZ healthcare system comprises a three-tier structure; primary, secondary and tertiary care. Registered primary healthcare practitioners include MSK practitioners as well as medical health practitioners (Ministry of Health, 2014b). Primary healthcare providers are those whom the public can make first point of professional health contact. This primary healthcare role involves disease prevention, health education and promotion (Health Issues Centre, 2015). Primary healthcare practitioners require a thorough understanding of pathophysiology and diseases or conditions that might be encountered in practice. This knowledge is necessary so that appropriate referral to other healthcare practitioners and services can be clinically justified when the presenting case requires more information or is suspected to be out of the scope of the primary healthcare practitioner (Vaughan, Macfarlane, & Florentine, 2014). Secondary practitioners are not involved in the first point of contact of patients but rather involve a referral from a primary practitioner for specialised services such as medical imaging and laboratory investigations. Secondary services can be utilised to further investigate or manage a clinical issue. The tertiary tier of care involves complex cases which require the interaction of several specialised professions (Health Issues Centre, 2015).

In NZ, the medical system is predominantly publicly funded (83.2% of medical claims are funded publicly but also comprises private and non-governmental sectors (Cumming et al., 2014). The National Health Board is a body within the MOH which allocates funding. The MOH advises the government on health and disability policies. Other contributing government agencies are the Office for Disability Issues, Ministry of Social Development, Maori Development, Pacific Island Affairs, Te Puni Kokiri (Ministry of Maori Development) and the Accident Compensation Corporation (ACC) (Cumming et al., 2014). ACC paid for 8.4% of all publicly funded cases in 2010 (Cumming et al., 2014). As a NZ is a Crown Entity, ACC provides compensation for accident based injuries through

no-fault, fully comprehensive, insurance schemes. It covers all members of the public and is funded by those that are self-employed, employees and employers. The ACC funds both public and private sector treatment for accident related care (Cumming et al., 2014). In the context of musculoskeletal care, practitioners make claims under ACC on behalf of patients, allowing them to access subsidised treatment of their injury. ACC funded treatment includes a wide range of rehabilitation services, as well as imaging and specialist services such as surgery when appropriate.

## Musculoskeletal practitioners registered within New Zealand healthcare system

The health and disability policies use several Acts as a guide for health professionals. These include the Health and Disability Services Act (2001), and the Health Practitioners Competence Assurance Act (HPCA) (2003). The Health and Disability Services Act underpins the certification of practitioners in mental, medical, surgical, geriatric, obstetric and other health-related services (Cumming et al., 2014; Health and Disability Commissioner, 1996). Similarly, the HPCA Act (2003) provides a framework from which health practitioners can be regulated to protect both themselves and the public (Ministry of Health, 2012). Of the professions regulated under the HPCA Act (excluding medical doctors), the main practitioners who focus on musculoskeletal care are osteopaths, physiotherapists, podiatrists and chiropractors (Ministry of Health, 2014a). Of these, the largest profession is physiotherapy with >4000 practitioners in NZ (Physiotherapy Board, 2014). Chiropractic and osteopathy are smaller professions, considered a part of the Complementary and Alternative medicine (CAM) group which includes professions that are not generally considered a part of conventional or publicly funded medicine. These are the only two professions within CAM that are regulated by the HPCA Act (Cumming et al., 2014). The HPCA framework ensures that health practitioners are regulated under the Act, and that these practitioners' practice within their scope as specified by their regulatory authorities (Ministry of Health, 2014a). Scope of practice can include tasks that are regularly performed by the practitioner within the context of their profession covering areas such as education, conditions and according treatment or management (Ministry of Health, 2015b).

The key professions that are the focus for this study are musculoskeletal practitioners; physiotherapists, osteopaths, chiropractors, and podiatrists. These are all potential users of MSK US and are introduced below.



## *Physiotherapy*

Physiotherapy provides services that develop, maintain, restore and optimise health. The service provided aims to aid those compromised by injury, disease, aging and environmental factors. It uses the principals of promotion, prevention, intervention, rehabilitation and habituation (Physiotherapy Board of New Zealand, 2014). The Physiotherapy Board of New Zealand has created and upholds competency standards in professional and ethical practice that is patient centred, demonstrating cultural respect and always acknowledging the patients' autonomy. Physiotherapists aim to integrate biomedical knowledge to demonstrate an evidence-based approach which involves continual reflection (Physiotherapy Board of Australia & Physiotherapy Board of New Zealand, 2015). Part of this integration involves utilising other healthcare services and involving them in their management of a patient. In NZ, physiotherapists have had the ability to directly refer patients for plain film x-ray and ultrasound since 1999. Physiotherapists are regulated by the Physiotherapy Board of New Zealand which bases its competency standards on the HPCA act and the Health and Disability Code of Consumers Right (Physiotherapy Board, 2014).

Imaging research in NZ regarding MSK US use by MSK practitioners has only included physiotherapists (Ellis et al., 2018; Jedrzejczak & Chipchase, 2008; S McKiernan, Chiarelli, & Warren-Forward, 2011; Roberts, Winner, Littlejohn, et al., 2006). One NZ study used standardised questionnaires and face-to-face interviews to examine the protocols of imaging referral with physiotherapists (Roberts, Winner, Littlejohn, et al., 2006). Roberts et al. (2006) collected information on referral technique, frequency of referral, confidence and education level. Fifty-two private-practice based physiotherapists participated and 96% of them thought further education on MSK US imaging would be beneficial. Further to this only 79% knew they were able to refer for MSK US (Roberts, Winner, Littlejohn, et al., 2006). This demonstrates the lack of education and availability of referral protocols for MSK US.

## *Osteopathy*

Osteopathy is a manual therapy based on three founding principles (Tyreman, 2013). These have been adapted over time to provide the basis of contemporary osteopathy treatment. The principles include that the body functions as a unit and that it holds mechanisms that can regulate self-healing. Thus, structure and function are regarded as interrelated (Tyreman, 2013). The founder of osteopathy, AT Still, had an inquisitive and adaptive approach to treatment which has resulted in osteopaths today tailoring and evolving examination and treatment according to the patient (Cotton, 2013). In contemporary practice this tailoring utilises an evidence based medical approach; this is the integration of patient values, clinical expertise and research evidence to create a well-rounded

informed opinion (Fryer, 2008). In NZ, osteopaths are governed by a regulatory authority, The Osteopathic Council of New Zealand (OCNZ). OCNZ also bases its competency standards on the HPCA Act and the Health and Disability Code of Consumers Rights (OCNZ, 2013; Stone, Hager, & Boud, 2009).

Although no information was specifically found in this study's review of literature on the education of osteopaths about imaging and referral in NZ, similar educational qualifications for osteopaths in Australia include units on how to interpret imaging results (Vaughan et al., 2014). The scope of osteopaths in NZ includes 'Critical Analysis' (Stone et al., 2009). This aspect involves interaction and communication with other healthcare professionals for services. This includes referrals for imaging such as plain film X-Ray and MSK US. Such interaction between osteopaths and other health professionals enhances the quality of information associated with a patient's health status by acquiring and then synthesising information into a suitable working diagnosis (Stone et al., 2009).

### *Chiropractic*

Chiropractors focus on primarily the structure of the spine and the function of the associated structures, namely the nervous system. Chiropractors focus on promoting, preserving and restoring the structure and function relationship. This includes the assessment of both spinal and non-spinal articulations. This can include either taking or ordering plain film X-Ray imaging (New Zealand Chiropractic Board, 2004; Royal College of Nursing, 2008). Plain film X-Ray can be used to determine the integrity of the spine and associated articulations. Further to this they can refer for the use of other imaging modalities including MSK US. With this information they can perform adjustments (high velocity low amplitude thrusts) and manipulations (direct thrusts) to treat the condition (New Zealand Chiropractic Board, 2004). Although chiropractors treat the axial skeletal system, they are also able to adjust peripheral joints and hence still have a use for MSK US which is primarily used to assess peripheral joints (Henderson et al., 2015a).

### *Podiatry*

Podiatrists specialise in foot care. As a primary care provider this involves preventing, identifying and managing surgical and medical conditions pertaining to the feet and lower limbs. This role encourages support and educates on lifestyle changes which can include, but is not limited to, rehabilitation following injury or surgery (Podiatry New Zealand, n.d.). Podiatrists are governed by the Podiatrists Board of New Zealand and are regulated under the HPCA Act which governs ethical standards of practice (Podiatrists Board of New Zealand, 2016). Their scope can be extended to include radiographic imaging and or minor surgeries (Podiatry Board of New Zealand, 2017).

This industry is aiming to move towards a plan of care than integrates multiple facets of the health services (Rome, Gow, Dalbeth, & Chapman, 2009). The inclusion of ultrasound in this is increasing in rheumatology fields and in non-musculoskeletal fields (such as in vascular imaging) (Bowen et al., 2008; Normahani, Powezka, Aslam, Standfield, & Jaffer, 2017). Novice training in MSK US has shown significant promise as results align with opinions of radiologists particularly when identifying bursitis, synovitis and erosion (Bowen et al., 2008).

## **Musculoskeletal ultrasound**

Ultrasound has been traditionally used as a diagnostic tool within the medical disciplines. More recently it has expanded to be used by other professions within the medical community including musculoskeletal practitioners to diagnose and aid rehabilitation of injuries. MSK practitioners use it to focus primarily on structural integrity and morphological characteristics of neuromusculoskeletal structures (Henderson et al., 2015a). MSK US is also used for detecting areas of fluid collection, examining cartilage and bone surfaces (Bates, 1996).

### **An overview of ultrasound technology**

#### *How ultrasound produces an image of underlying soft tissues*

Ultrasound creates high frequency sound waves, which are formed as they pass through the transducer crystals in the ultrasound probe, which travel through tissues in the body to form images of it. As the sound waves propagate through a medium, such as muscle tissue, particles move in an oscillatory motion creating areas of compression and energy change. The ultrasound image is produced by the echo or reflection of the sound waves as it returns from its impact with tissue (Bates, 1996; Whittaker & Stokes, 2011). How these waves reflect depend on the transmitted current, probe type, and resistance of tissue. As it impacts tissue some energy is lost as it is reflected, however, some continues to a greater depth. This response is known as acoustic impedance, and is altered by the density of the tissue. Once reflected and received by the probe, the probe converts the waves into an image by calculating three variables; vertical placement (time taken for the echo to return), horizontal placement (locations of returning echo) and brightness (strength of echo) (Whittaker & Stokes, 2011). This process is repeated continuously until the converted electrical pulse produces an image on a screen.

#### *Safety of ultrasound*

The increase in acuity of the ultrasound image has historically correlated with a higher acoustic output. The side effects of this include a subsequent heating of tissues (particularly bone), mechanical

disturbances and pressure changes in tissues. Temperature increases may have adverse effects on sensitive organs and an embryo/foetus. Temperature rises are thought to increase mineralisation on bone surfaces and adjacent tissues. This means possible embryo/foetal structures that could be affected are spinal cord and brain structures (World Federation for Ultrasound in Medical and Biology, 2012). The output of the probe can also have an inertia-based effect on tissue state, causing disruption of molecular bonds, resulting in small gas bubbles to cavitate and release energy (Bates, 1996). Non-thermal effects have been shown in animals however these have not been demonstrated in humans, except when using a microbubble contrast agent (World Federation for Ultrasound in Medical and Biology, 2012).

### *Limitations and reliability of musculoskeletal ultrasound*

Ultrasound has its limits, such as depth of structure and image resolution. These are determined in part by sonographer expertise and probe used. Depth and resolution are also limited by the available technology and structure that can impede view such as cortical bone (Bates, 1996; Henderson et al., 2015a; Whittaker et al., 2007). For example, the use of MSK US in spinal structure, namely spinal canal diameters, intervertebral disc and nerve roots, sparked the interest of chiropractic groups. However, this idea was abandoned as the technology was unable to penetrate to an adequate depth, resulting in poor image quality (Henderson et al., 2015a). Ultrasound, like all medical imaging, also does not provide information on the entire clinical picture. This information relies primarily on the information provided on the referral form or on the sonographer's own case history taken with the patient (Necas, 2017). This is one of the elements that contribute to the outcome variance between operators. Other factors that contribute include knowledge of pathologies, anatomical anomalies, and the machinery used by the operator and the corresponding accuracy of imaging,

The real-time aspect of MSK US means sonographers are involved in the interpretations of images as they are produced. This is an advantage as it allows structures to be more dynamically assessed. This is different to a plain film X-Ray which is largely interpreted by the radiologist after the image has been taken. Radiologists are consulted to sign off the opinion of the sonographer as the diagnosis. A study in 2010 conducted an audit of sonographer reporting and compared it to that of a radiologist (Riley, Groves, & Chandramohan, 2010). It found that the radiologists agree with the opinion of the sonographer in 94.8% of cases, finding a major discrepancy in only 1 out of 248 cases (Riley et al., 2010). This demonstrates that although the accuracy of the technology is operator dependent, that there is good inter-profession reliability between radiologists and sonographers.

Intra-profession reliability has also been examined. The expertise and corresponding level of accuracy was recently compared between a sonographer who was specialised in MSK US and a general practitioner who had been trained in sonography (general sonographer). 299 patients were scanned. Cole et al. (2016) found that MSK sonographers had higher sensitivity and specificity rates when examining the shoulder for rotator cuff tears. This led to an overall higher accuracy rate of 97% for the MSK sonographer compared to 85% found with the general sonographer (Cole et al., 2016). This suggests that the expertise of the sonographer should be considered by the MSK practitioner particularly when referring for complex cases.

## Development of interest of ultrasound by health professions

As ultrasound technology has developed there has been a surge in the use of MSK US by non-radiologists, including sonographers, with a four-fold increase in the use of MSK US in the United States since 2000 (Henderson et al., 2015a; Riley et al., 2010). This is probably due to the availability of more affordable, compact and portable systems. There have been significant refinements of the 2D technology, producing images approaching, and in some applications exceeding, that of Magnetic Resonance Imaging (MRI) (considered the gold standard of medical imaging), due to the use of higher transducer frequencies (>15MHz) (Henderson et al., 2015a). Ultrasound has several advantages over MRI including that it provides real-time feedback allowing the sonographer to examine structures in different positions and whilst the patient completes specific movements. It is also more tolerable to patients enabling the evaluation of several joints in one sitting (Blankstein, 2011b; Kang et al., 2013).

These technological advances in USI have stimulated interest from many clinical practitioners in several medical specialisms. For example, emergency specialists have used ultrasound to detect foreign bodies which are often missed in lacerations and penetrating wounds (Blankstein, 2011a). Rheumatologists have started to use it for the identification of structural damage and inflammation in joints and for monitoring these aspects in association with therapeutic treatment. Specialisms such as these are now working on standardising this process (Kang et al., 2013).

## Use of musculoskeletal ultrasound as a diagnostic tool

The current technology of diagnostic MSK US is largely limited to the diagnosing pathologies in the

more superficial layers of the extremities. However, this provides the means to evaluate and differentiate a wide variety of common injuries. Below is a brief review of characteristics of tissue and conditions MSK US is commonly used to examine.

## Characteristics of tissues commonly examined in MSK US

There are three tissues commonly examined to determine a diagnosis in MSK US. These are tendons, ligaments and muscles. One of the key elements examined is collagen because the density of it correlates positively with sound reflection. A higher density will appear as a more white/brighter image on-screen which is the opposite of tissues without collagen such as fluids. These do not reflect the sound waves and hence appear “hypoechoic” or black (Whittaker & Stokes, 2011). The level of reflection is called echogenicity which indicates composition (fluid or collagen level). The other class of information obtained from the image is architecture of tissue; shape, size, internal structure and position. This can be used to determine cross sectional area of tissue when examining level of contraction such as in rehabilitative ultrasound imaging (RUSI) (Whittaker & Stokes, 2011).

### *Tendons*

The appearance or echotexture of the tendon is examined by inspecting the tendinous architecture, which includes elastin (2%), proteoglycans (68%) and collagen (30%) (Bates, 1996). A key aspect of the tendon is the musculotendinous junction (where the muscle and tendon connect) because it is where vascular structures pass. The level of vascularity shows the maturity of the tendon, increasing with development. When the tendon is subjected to a load it is unable to endure, changes occur causing hypovascularity, necrosis, neovascularisation and dystrophic calcifications (Bates, 1996). An example of a cause of these changes is that which results from overuse in sports people. Common sites for this to occur include the rotator cuff, patellar and achilles tendons. The pathological change that often occurs is called tendinopathy (Rees, Maffulli, & Cook, 2009). Tendinopathies show with reduced echogenicity, increased thickness due to structural change that results from water absorption, and microtears (Bates, 1996). These characteristics combine to represent different stages of tendinopathy which require different rehabilitation and treatment plans (Cook, Rio, Purdam, & Docking, 2016; Rees et al., 2009).

Other injuries to the tendon include tears. A partial tear will show with an echo-rich centre surrounded by an echo-poor area suggesting peri-leisional fluid. This compares to a complete tear which is more

distinct as it shows a change to the outline of the tendon or no tendon at all (Bates, 1996).

### *Ligaments*

Ligaments mostly consist of Type 1 collagen. Like tendons, these are arranged in fascicles, however are more irregular in appearance and can have adipose or synovia in between them. The most commonly examined ligaments are those that are extra-articular and are torn or left unstable by trauma. An example of this is the lateral ligament complex of the ankle. Clinical evaluation is often used to make a diagnosis however can be misinterpreted in up to 50% of patients due to local inflammatory effects such as oedema (Bates, 1996).

Similar to tendons, partial tears result in hypoechogenic and thickened areas while complete tears disrupt the fascicular structure creating a wavy line or discontinuity. These are often accompanied by oedema or bleeding if acute or subacute, and can involve an avulsion fracture of attached bone. Oedema starts seven days after injury, and evidence of discontinuity does not begin to appear until 5 weeks (when the scarring process is seen as increased echogenicity) (Bates, 1996). Hence the time between date of injury and scan date are useful details for the sonographer to have.

### *Muscle*

Muscle is structured similarly to tendons and is classified according to elastic (fast or slow twitch fibres, which more commonly rupture) or non-elastic tissue (fascia, vascular structures and nerve fibres). The non-elastic elements show as echo-poor whilst the elastic elements are the reverse. Although each muscle fibre is not visible (as the endomysium is not visible), the orientation of the perimysium (if longitudinally viewed) or epimysium (if transversely viewed) will be arranged in parallel and hence delineation of the fibres suggests injury. The level of stretch, continuity of fibres and bleeding is then used to grade the level of rupture. Within 48 hours a haematoma forms hindering view. The process of healing begins following this and can take up to 4 months to complete. It is shown with an increase in area of echo-rich muscle (Bates, 1996). This also demonstrates the utility of injury date information.



## **Anatomic regional uses of MSK US**

This section provides an overview of the used of MSK US according to body region. Key references used in this section includes those by Blankstein (2011) and Henderson et al (2015). Henderson et al (2015) conducted a review of literature, extracting data to complete an appraisal of studies investigating accuracy of MSK-US. The conclusion of the study was that MSK-US overall has good diagnostic accuracy for a wide range of soft tissue pathologies however there is a lack of high quality prospective experimental studies hence accuracy could be overestimated. The article written by Blankstein is peer-reviewed and provides an overview of ultrasound uses diagnostically in orthopaedics.

### *Neck*

Ultrasound is most useful in soft tissue structures. This can include distinguishing calcifications, muscle ruptures, haematomas and true tumour masses. It can also be used in new-borns to diagnose clavicle pseudo arthroses and fractures (Blankstein, 2011a).

### *Shoulder*

The shoulder is one of three areas in the body that ACC recommends using ultrasound as an imaging modality (Accident Compensation Corporation, 2011). Most patients present with pain due to overuse and or degeneration (Blankstein, 2011a). However many shoulder issues often present with similar symptoms and signs, making it difficult to diagnose definitively (Blankstein, 2011a; Henderson et al., 2015a). ACC primarily suggests using MSK US in the case of a suspected rotator cuff dysfunction (Accident Compensation Corporation, 2011). Musculoskeletal ultrasound can discriminate rotator cuff full thickness tears to a high discriminatory level and similarly partial thickness tears and rotator cuff atrophy can be ruled in relatively easily. MSK US is considered an early diagnostic protocol, surpassing other conventional modalities because of its ability to discern a wide variety of other pathologies. These include subacromial bursitis, subacromial impingement, rotator cuff tendinopathy, calcific tendinopathy and long head of biceps pathologies (Blankstein, 2011a; Henderson et al., 2015a). It is also used for detecting bone and joint pathologies such as humeral fractures (these show cortical discontinuity), sternoclavicular and acromioclavicular dislocation or arthritis (Blankstein,

2011a).

### *Elbow*

There is less evidence in this area with regard to MSK US. MSK US is documented for its use in diagnosing distal biceps tendon tears, cubital tunnel syndrome and lateral or medial epicondylalgia (Henderson et al., 2015a). It has also been suggested to be of use in detecting loose bodies, rheumatoid nodules, areas of calcification and changes in synovial composition (Blankstein, 2011a).

### *Wrist/Hand*

Musculoskeletal ultrasound has become increasingly utilised in the diagnosis of carpal tunnel syndrome. An ACC document for the care pathway of distal limb conditions says MSK US may be used as an early diagnostic option for carpal tunnel by examining nerve conduction (Grimmer-Somers et al., 2009). Previously this has been primarily diagnosed using electrodiagnostic studies (used to determine function of nerves and muscles). However, these can be difficult to use in assessing surrounding structures and can be uncomfortable for the patient (Henderson et al., 2015a). ACC does not suggest MSK US for routine use in cases of De Quervain's disease or other tenosynovitis conditions (Grimmer-Somers et al., 2009). However, MSK US has been useful in detecting the presence of an 'intracompartmental septum', this has been known to complicate non-operative options leading to a poorer prognosis in those with de Quervain's disease (Henderson et al., 2015a). It has also been useful in examining ganglionic cysts, the triangular fibrocartilage complex, intrinsic wrist ligaments as well as other common structures such as neoplasia and tendons (Blankstein, 2011a; Henderson et al., 2015a).

### *Hip*

The hip has a complex anatomical structure with most elements lying deeply, thereby challenging the capabilities of current MSK US technology. However, it is indicated for use in meralgia parasthetica, trochanteric bursitis and gluteal tendon tears (Henderson et al., 2015a). The use of MSK US as a tool for distinguishing the true source of pathology has been useful in this area. For example, a study in 2013 found that true hip bursitis is rare when compared to the pathologies of the overlying tendons of the gluteus medius and minimus (Long, Surrey, & Nazarian, 2013). There appears to be a deficit in

the validation of this tool in hamstring injuries which MRI is currently used to examine (Henderson et al., 2015a). It is also thought to be of use in detecting elements of Perthe's Disease and hip dysplasia in children (Blankstein, 2011a).

### *Knee*

The ACC imaging guidelines for soft tissue knee injuries recommend MRI as the main imaging tool for the knee. This is excluding those who have undergone Ottawa Knee testing and have been consequently referred for plain film X-Ray (Accident Compensation Corporation, 2003). However, MSK US is being used to review cruciate ligaments, menisci, collateral ligaments and posterolateral structures (Vertigo et al., 2007). MSK US is a much lower cost alternative for examining some of these structures than other imaging modalities such as MRI. There are a variety of widely used orthopaedic clinical tests, however, synovitic proliferations and small effusions can be missed in a typical examination. Joint effusion and other bony changes when identified can be used to diagnose early stage osteoarthritis (Blankstein, 2011a). MSK US has been shown to have high diagnostic value in discriminating meniscal cysts, Baker's cysts and full quadriceps tears (Blankstein, 2011b; Henderson et al., 2015a). If used in conjunction with orthopaedic testing it has been found to be superior to MRI in detecting plica injuries (Henderson et al., 2015a). It is also useful for distinguishing the various stages of patellar tendinopathy, aiding appropriate management (Cook et al., 2016). The posterolateral structures (popliteus, LCL) are also of moderate to high diagnostic value. However, they are commonly injured with other structures that are beyond the capabilities of MSK US such as the cruciate ligaments (Henderson et al., 2015a). Damage to medial structures such as the medial collateral ligament can also be examined to high specificity pinpointing the key areas for treatment (Blankstein, 2011a). MSK US is, however, not of an appropriate method for investigating meniscal tears and most intra-joint ligaments due to the depth of these structures (Henderson et al., 2015a).

### *Ankle and Foot*

Up to 75% of patients will have chronic symptoms or recurrent strains following an initial ankle sprain (Hubbard & Wikstrom, 2010). The anterior talofibular ligament (ATFL) is the most commonly injured ligament in ankle sprains. 10-20% of people that injure the ATFL will develop chronic lateral ankle instability which predisposes them to other ankle pathologies such as arthritis (Hubbard & Wikstrom, 2010; Jung, Kim, Choi, & Shim, 2013). Hubbard and Wikstrom (2010) suggest that since

so many people continue to have ankle issues following injury, current rehabilitation protocols may not be effective (Hubbard & Wikstrom, 2010). It is important to note that there were no ACC guidelines found for the ankle/foot region. Given the real-time nature of US, a new application has been made to examine ankle stability by combining MSK US with a simple stress test. This has been shown to be of the same accuracy as MRI (Cho et al., 2016). Other ligamentous structures that can be examined by MSK US include the calcaneofibular, deltoid, and syndesmotoc ligaments.

Tendinopathies and tears can also be examined to a good diagnostic standard, including those of plantaris, peroneal, tibialis posterior, and plantar fasciitis (Henderson et al., 2015a). MSK US is useful in differentiating Achilles tendinopathy with these conditions as well as Haglund's deformity and Sever's disease (Blankstein, 2011a; Henderson et al., 2015a).

## Rehabilitative musculoskeletal ultrasound

The use of ultrasound began in the 1950's to examine visceral organs and soft tissue. Since the late 1990's ultrasound was evaluated for its use in rehabilitation of neuromusculoskeletal disorders. This is when it first gained the label Rehabilitative Ultrasound Imaging (RUSI). RUSI was defined as a process that physical therapists could use to examine the function of muscle and its related soft tissue (Teyhen, 2007). The use of RUSI is of increasing interest to MSK practitioners because it allows them to better understand the relations between motor control and function during specific exercises (Minister of Health, 2016; Teyhen, 2007). It utilises the diagnostic capabilities of ultrasound to examine activation of muscles by recording muscle density, size and level of contraction (Heidari, Farahbakhsh, Rostami, Noormohammadpour, & Kordi, 2015). Muscles commonly assessed using RUSI include those of the lower trunk (multifidus, rectus abdominus, pelvic floor) and RUSI has expanded to include peripheral joints such as the shoulder as well as movement pattern disorders (Ghamkhar, Emami, Mohseni-Bandpei, & Behtash, 2011; O'Sullivan, McCarthy Persson, Blake, & Stokes, 2012). An example of RUSI is its use in the lower back. Initial studies attempted to use MSK US to examine spinal canal diameter. However, more recently researchers have examined the role of surrounding trunk and paraspinal muscles in stabilising lumbar vertebrae using MSK US instead of MRI or CT (computed tomography) (Heidari et al., 2015). RUSI in this area has been shown to have good inter-rater reliability and is comparable to MRI and electromyography (Hebert, Koppenhaver, Teyhen, Walker, & Fritz, 2015; Heidari et al., 2015). Additionally, studies have found RUSI is more accurate than palpation of muscle activation in some areas such as multifidus in the lower back (Hebert et al., 2015). A more specific example of RUSI is its use in people with chronic low back pain (CLBP) and quantifying the atrophy of lumbar multifidus muscles responsible for segmental control.

(Dominick, Blyth, & Michael, 2011; Swain & Johnson, 2014). Heidari et al's review of literature suggests a reduction in neuromuscular control is thought to predispose patients to chronic low back pain as it disables the patient to regulate paraspinal muscle contraction around the vertebrae. Changes to the muscles also occur including atrophy (unilaterally with corresponding unilateral pain), reduced density and fatty infiltration of muscle fibres (Heidari et al., 2015). Multifidus cross-sectional area can be improved by targeted training which has had an inversely correlated effect on low back pain (Hides, Stanton, McMahon, Sims, & Richardson, 2008). As RUSI is taken in real-time, it allows the patient to see the muscle activate, confirming whether the muscle is being activated by a prescribed exercise.

## **Ultrasound within the context of New Zealand health and research**

In NZ, health providers registered with ACC are able to refer for ultrasound and plain film X-Ray services as recognised by the ACC (Roberts, Winner, Littlejohn, et al., 2006). ACC funds the majority of imaging for DHBs within a period of 6 weeks following the accident/onset of injury (National Health Committee, 2015). The set fees for MSK US by ACC range between \$148.17 (RU31 US Musculoskeletal) and \$195.97 (RU30 US Shoulder) including tax (Accident Compensation Corporation, 2016; Elias, 2015).

### **Current referral guidelines for ultrasound**

The guidelines for ultrasound use are limited, being referred to in only three ACC documents, two of which refer to in in the rehabilitative capacity, which are between 7 and 15 years old (Accident Compensation corporation, 2003; Accident Compensation Corporation, 2011; Grimmer-Somers et al., 2009). These documents encompass referral guidelines for imaging generally and include the ACC acute low back pain guidelines (Roberts, Winner, Littlejohn, et al., 2006). Other key imaging pathway documents are the Ottawa ankle and knee rules and the National Criteria for Access to Community Radiology (which refers only to shoulder for MSK US) (Ministry of Health, 2015a; Stiell et al., 1994; Yao & Haque, 2012).

There are a few institutes which outline what is likely to be involved in a MSK US by region (European Society of Musculoskeletal Radiology, n.d.; Society and College of Radiographers and British Medical Ultrasound Society, 2015; The Association for American Ultrasound, 2012). The American Institute of Ultrasound in Medicine has recommended what they believe is important to include in an ultrasound referral, not specific to MSK US, to achieve a high quality of patient care. Their guidelines suggest various patient and practitioner identification elements, as well as clinical information the practitioner deems relevant and appropriate according to the International Classification of Diseases (ICD) codes (AIUM: The Association for Medical Ultrasound, 2015). These also include the orientation of position of patient and briefly how structures will be examined (European Society of Musculoskeletal Radiology, n.d.; Society and College of Radiographers and British Medical Ultrasound Society, 2015; The Association for American Ultrasound, 2012).

## Current protocols and reporting guidelines for sonographers

The diagnostic accuracy of experienced sonographers has been shown in all subspecialties of ultrasound including MSK. As such, sonographers are becoming expected to perform an ultrasound, give an interpretation or diagnosis according to the real-time image and then write a formal report with the results. In Australia and New Zealand the sonographer reporting practice varies and is influenced by both level of professional expertise and specialty (Necas, 2017). Necas (2017) has outlined protocols to guide sonographers when writing reports following imaging (Necas, 2017). The sonographer involved in this study roughly follows this format (examples can be seen in [Appendix C](#)) as well as those of the European Society of Musculoskeletal Radiology's technical guidelines (European Society of Musculoskeletal Radiology, n.d.; Necas, 2017; Sound Experience, 2017). Necas (2017) also encourages sonographers to ensure they have a complete clinical picture of the case before commencing a scan. This can involve taking their own case history to confirm that the referral information is still relevant. This provides the sonographer with the opportunity to perform their own musculoskeletal assessment. For MSK US this could potentially involve observation, case history, palpation, and gross movement assessments. Palpation can be done using the transducer (sonopalpation) which gives the sonographer the unique ability to record imaging during patient movement whilst recording over a painful area (Necas, 2017). The specific scanning and reporting protocols used in each area are outlined by several professional bodies including the British Medical Ultrasound Society (BMUS), American Institute of Ultrasound in Medicine and European Society for Musculoskeletal Radiology (AIUM: The Association for Medical Ultrasound, 2015; European Society of Musculoskeletal Radiology, n.d.; Society and College of Radiographers and British Medical

Ultrasound Society, 2015). The elements included in the scanning protocols for this study can be seen in [Appendix D](#).

## Current research regarding clinical use of MSK US in New Zealand

There is little research about the use of MSK US from the perspective of the sonographer or MSK practitioner, particularly in NZ. There are four main studies that exist. Three examined the use of MSK US by physiotherapists but did not specifically describe whether this was RUSI or DUSI (Ellis et al., 2018; Jedrzejczak & Chipchase, 2008; S McKiernan et al., 2011). Although these are relevant as they give an indication of the general use of MSK US, they are not directly relatable to this study which is about referral patterns and resulting sonography reports. Whereas, Roberts et al., (2006) examined the protocols for imaging referral in NZ. They aimed to determine whether any procedures existed for physiotherapists referring patients for radiological imaging. Roberts et al., (2006) hypothesised that because of a lack of protocol for referral there would be no consistent procedures for physiotherapists (or any other manual therapists). To investigate, fifty-two physiotherapists in Wellington participated in an interview and questionnaire. Of those who participated all knew they could refer directly for plain film X-ray but only 41 (79%) knew they could refer for ultrasound. Nearly all respondents (n=50, 96%) indicated they would like more information on ultrasound. Aspects they wanted information on included when to refer (63%), how to interpret results (21%) and what protocols they needed to follow (12%). This study also asked what information the practitioners included in their referral for imaging. The most common were diagnosis query (73%), mechanism of injury (MOI) (62%), relevant history (56%) and relevant symptoms (38%). This contrasts with the indications for plain film X-ray referral which were positive ACC/Ottawa testing, persistent swelling and a lack of improvement (Roberts, Winner, Littlejohn, et al., 2006).

Similar studies were conducted in one of NZ's closest neighbouring countries, Australia. Both used questionnaires to examine usage of and access to MSK US by physiotherapists and evaluated the level of training they had received on MSK US (Chipchase & Jedrzejczak, 2006; McKiernan et al., 2011). These studies were ambiguous as to whether the physiotherapists use of MSK US was in a rehabilitative or diagnostic capacity. However, they reinforced the key points that both access to MSK US and training in MSK US is low for physiotherapists. Jedrzejczak and Chipchase found only 11.6% of respondents (680 out of a possible 1328 people mailed) used an ultrasound machine, despite 65% of respondents working in the MSK field (Chipchase & Jedrzejczak, 2006). McKiernan et al. (2011) focussed more on how training levels affected usage of MSK US. Training included education in both image interpretation and operation of an ultrasound machine (Jedrzejczak & Chipchase, 2008; McKiernan et al., 2011). The low usage rates in this study were most commonly due to low access or

a lack of knowledge about MSK US (McKiernan et al., 2011). McKiernan et al. (2011) later completed a study which concentrated on evaluating self-reported training time. This varied a lot between practitioners, 67% received only “several hours” of education on diagnostic ultrasound (McKiernan et al., 2011). Use of MSK US within private practices by physiotherapists was largely for biofeedback of trunk muscles such as abdominals, pelvic floor and multifidus (in descending order of use) (Jedrzejczak & Chipchase, 2008; McKiernan et al., 2011). McKiernan et al. (2011) suggested that given the limited training and use of MSK US, the scope of practice for physiotherapists with regards to using MSK US, needed to be questioned. Hence, they encouraged the development of guidelines and codes of practice by professional bodies.

Ellis et al. (2018) also questioned where MSK US lies in terms of scope of practice for physiotherapists in NZ. They examined the use of ultrasound by physiotherapists. Over 400 responded to an invitation to complete a questionnaire (9% of all physiotherapists in NZ), only 24% reported actual use of MSK US. In the study by Ellis et al., key barriers to utilisation of MSK US were a lack of training (74%), lack of direct access (72%), and lack of knowledge about uses of MSK US (23%). These responses are similar to those found earlier by McKiernan et al. (2011) (Ellis et al., 2018; McKiernan et al., 2011). Ellis et al. (2018) asked participants whether they thought the use of MSK US by physiotherapists was within scope of practice and 47% responded “I don’t know”. The infrequency of MSK US use was exacerbated by a low level of training with the majority of respondents having received informal training or no training at all (Ellis et al., 2018). The Physiotherapy Board of New Zealand’s General Scope of Practice has a reasonably broad outline of scope with regards to specific assessment tools. It does, however, state that an appropriate level of education and competency in these tools is required to use them (The Physiotherapy Board of New Zealand, 2009, 2015). It is important to note that there were a relatively small number of participants in the study by Ellis et al. (2018) and that published information on other professions’ (osteopathy, chiropractic, podiatry) use of MSK US with regards to referral and use procedures, was not available.

## **How this project ties in with the NZ Health Strategy**

A key aspect to examine in exploring the procedures for MSK US by MSK practitioners is the process of referral for MSK US. By providing the most relevant aspects of the case history and clinical examination, the sonographer is provided with a better picture of the condition and, therefore, can employ the most appropriate protocols and techniques during the imaging (Necas, 2017). MSK practitioners benefit from this also, as it provides a more tailored imaging session for their patient.



Similarly, by visualising the musculoskeletal structure of concern, the management plan of the MSK practitioner could more accurately address the issue. Palpation is a major tool currently used by MSK practitioners, however, it is subjective and has limited accuracy (Kilby et al., 2012). To illustrate the problem of accuracy, the work of Kilby et al. (2012) is illustrative. Kilby et al (2012) compared the manual palpation of the fourth lumbar vertebra and both left and right posterior superior iliac spines by nine physiotherapists on three different subjects. The landmark was checked using MSK US and it demonstrated a mean  $\pm$  SD error of  $15.63 \pm 3.89$ ,  $20.07 \pm 4.60$ mm,  $20.59 \pm 2.79$ mm(Kilby et al., 2012). Another example also using MSK US to examine accuracy of palpation was done by Mieritz and Kawchuk, (2015). They examined the palpation accuracy for lumbar vertebrae by chiropractic students. Although these students were still in training their landmark identification had a range of  $32 \pm 19$ mm. Musculoskeletal ultrasound, however, demonstrated 100% accuracy for identifying the vertebrae. This indicates the potential of MSK US for identifying an affected structure (Mieritz & Kawchuk, 2015).

MSK US can complement the existing orthopaedic tests and palpation of structures to identify pathological structures, streamlining management plans. This fits in well with the NZ MOH Health Strategy which describes 5 key themes to pursue over the next 10 years. These aim to make healthcare 'people powered', 'closer to home', make the healthcare of high performance and value; and to do this using 'one team' combining to make 'one smart system' (Ministry of Health, 2016). Part of the MOH's plan is to ensure funding is optimally directed. To help achieve this, government agencies monitor outcomes arising from the services that are being provided. Ultrasound is an example of an under-studied area within the NZ health system. Specific reports were requested asked to be generated from the ACC database. It found that, in 2016, there was over 38,536 claims for MSK US (including *service items U30- US Shoulder, U31- US Musculoskeletal, U39-US Skeletal Miscellaneous*) that were made in Auckland alone yet there were very few studies examining how MSK practitioners' were referring, what they were referring for and how this measured up to the outcome of the ultrasound (Piuila-Afitu, 2018a, 2018c). Answers to these questions would help to begin the analysis of MSK US as a service within the health system.

There are a limited range of imaging guidelines which suggest best practice for MSK practitioners when referring. No guidelines exist specifically for MSK US referral; hence, research is required to determine what these should be. As MSK US is a relatively inexpensive tool that has a low safety risk there is an argument that it should be more readily utilised (Ministry of Health, 2015a; World Federation for Ultrasound in Medical and Biology, 2012). Musculoskeletal ultrasound also connects primary and secondary healthcare providers because it provides real-time diagnoses. These can optimise efficiency of treatment and management by supplying more accurate knowledge of tissue injury (when combined with clinical expertise and patient feedback).

This study therefore aims to investigate the existing referral patterns by MSK practitioners in NZ for MSK US. This study will achieve this by examining descriptive characteristics of a random sample of 1000 cases referred to one sonographer in a private MSK US practice in 2016 located within an osteopathy tertiary teaching clinic in Auckland, NZ. This study aligns with the “smart system” aspect of the NZ Health Strategy because it will provide descriptive information on a developing technology, which could then be used in further studies to create and update referral guidelines for MSK US (Minister of Health, 2016).

## **Conclusion**

Musculoskeletal ultrasound is an inexpensive tool that can be used by MSK practitioners to provide real-time feedback on function and pathology of specific structures. The limited existing research suggests it is an underutilised tool possibly due to limited training and access. This thesis project has been devised on the basis that increasing knowledge of MSK US could reduce cost and time for identifying conditions, thus, allowing patients to be treated more effectively. This aligns with the NZ Health Strategy of 2016 which aims to encourage multidisciplinary patient-centric care.

The primary focus of this thesis will be to report descriptive information on the patients and professions referring for MSK US. It will examine elements included in a referral and the sonography report. As the literature review revealed there is little information on the use of MSK US by practitioners. By creating a preliminary study investigating descriptive information surrounding MSK US, the beginnings of a platform of information will be created. This information could be used in further research from which referral protocols could be developed. The study sheds light on aspects that could improve the quality of the current system to aid both referrer and sonographer. This will help to formalise the interface between primary and secondary health care professionals as represented by MSK practitioners and musculoskeletal sonographers.

# CHAPTER 3 METHODS

## **Methodology**

A ‘case’ is defined as a “unit of human activity embedded in the real world which can only be studied in context from which precise boundaries are difficult to draw”(Gillham, 2010). This research examined a single ‘institution’ in the form of a diagnostic imaging practice, Sound Experience Ltd located within an osteopathy tertiary teaching clinic. This case study started with a broadly defined research question and hence did not have *a priori* theoretical notations. These notations became more apparent as the wide range of evidence was collected and generalisable findings resulted. This is otherwise known as *inductive theorising* (Research Methodology, 2017). This approach was appropriate for the data that was collected here because the subject of this study had, to the authors knowledge, not been completed before, and therefore the hypotheses were too difficult to construct (Gillham, 2010). This study also aimed to create a preliminary descriptive data set, in order to inform the direction of the ‘institution’ that is MSK US and its interaction with referrers.

## **Design and Ethics**

Descriptive analysis of referral patterns set in one urban practice of one registered sonographer with a special interest in musculoskeletal ultrasound. The study was approved by the Unitec Research Ethics Committee under the provisions for non-contentious applications (Approval 2016:1083) (see [Appendix A](#))

## **Sampling and Eligibility**

A retrospective stratified random sample of 1000 cases were sampled from the total number of available records from one practice between 1 January 2016 and 31 December 2016. A ‘case’ was defined as a single referral form and the associated radiologist endorsed imaging report. The stratification was based on monthly case load such that the sample in each calendar month was

proportional to the number of cases scanned in that month.

## Eligibility

1. All records for which there was both a referral form and radiology report were eligible.
2. Date of scan was between 1 January 2016 and 31 Dec 2016.
3. Must be a referral for a musculoskeletal complaint.
4. Must not include requests for steroid injections.

## Data collection procedures

The physical records were all consecutively numbered with a unique identification number. A random sampling list was generated as there were more than 1,000 available records to use. This was done according to the range of identification numbers for each month and generated using excel formulae. The corresponding referral form and sonography report were retrieved for each randomly selected identification number and data was extracted and tabulated in a custom designed spreadsheet (see examples of referrals forms and sonography reports in appendices B and C)

The data was considered in two divisions: information from the referral request (paper-based referral slip); and information arising from the sonographer (sonography report letter) (see Table 1). These categories were developed with the sonographer as well as during the small pilot prior to beginning the data collection.

TABLE 1. DATA EXTRACTION CATEGORIES AS OBTAINED BY THE REFERRAL REQUEST AND SONOGRAPHER REPORT

Referral Request	Sonographer Report
Scan date	Scan date
Patient ID	Patient ID
Referrer name	Sonographer clinically indicated region
Referrers company	Sonographer Clinical indication for scan additional to Referrer
Referrers occupation	Tested region
Referrers location	Scanning routine for region
Patient DOB	Number of opinions that matched the referrer's queries
ACC – yes or no	Opinion matched to a SNOMED international edition description
Gender	SNOMED ID number associated with description of opinion
Requested region to be scanned indicated by check-box	
Clinically Indicted region by referrer	
Side to be scanned	
Time since injury	
Who the time since injury was indicated by	
Clinical indication/s of referrer which explain reasoning for referral	
Query matched to a SNOMED international edition description	
SNOMED ID number associated with description of query	

Abbreviations: ID = identification number, DOB = date of birth, ACC = Accident Compensation Corporation, SNOMED = Systematized Nomenclature of Medicine- Clinical Terms.

Systematized Nomenclature of Medicine- Clinical Terms. (SNOMED) coding was chosen to make the diagnoses more specific and to match the new coding system which will be used in the New Zealand health system, however, a release date has not yet been announced (Accident Compensation

Corporation, 2017). The edition used was the SNOMED International Edition 20170731 (International Health Terminology Standards Development Organisation, 2017). SNOMED codes were identified using the online search engine and copied into the spreadsheet to generate a look-up system.

There were two personnel involved in data extraction. Each had training in the musculoskeletal field. Their clinical experience allowed them to select the most appropriate option (or substitute) using the SNOMED system. Any diagnoses that could not be found were allocated the next most similar code that could be found. For example, there was no ‘tendinopathy’ option for any region so ‘tendinitis’ was substituted. Similarly, there was little specificity for structures attaching to the hip, hence more general codes were used such as ‘rupture of hip muscle’ rather than gluteus medius tear. For cases that were particularly difficult to decide the SNOMED code for, a third investigator was available to discuss. Any common phrases such as ‘Query any abnormalities’ that could not be found in the unique SNOMED code system were given another unique number.

## Time involved to extract data

To consider the feasibility of data extraction and to develop an extraction template a sample of 10 anonymised reports were processed prior to the main study. It was estimated that each report would take a maximum of 10 minutes to process. The estimate of the overall extraction time was therefore underestimated as it took a minimum of 166 hours. A research assistant was recruited and involved in entering approximately 250 entries.

## Reliability of extraction

To determine whether there were differences between the research assistant and principal researcher in extraction of data from the sources of the documents, a test of inter-rater reliability was undertaken. Briefly, the process was to create a random sample of five cases. The data from these cases were extracted as per the standard procedure by the principal researcher and the research assistant, and then again by the principal researcher. Extraction of each set was completed on separate days and in isolation to each of the other sets. The researcher and research assistant entered the same data on different spreadsheets to determine inter-rater reliability. The researcher repeated this a week later to determine intra-rater reliability.

## Eliminated data

Although the clinical focus of the sonographer is on MSK US (Sound Experience, 2017), a small number of referrals for general medical (i.e. non-musculoskeletal) scans were received in the 2016 calendar year. Data was not extracted from any referrals that were for non-musculoskeletal conditions as described by the “Referrer Check-box Region” or “Referrer Text Region”. This included: hernia, other, renal, scrotum, and thyroid. Referrals requesting steroid injections were also not included as these had little information about the presenting condition scanned and were often diagnosed at a prior date.

## Data analysis

Data was extracted from the spreadsheet (flat file source), and subjected to a data integrity check. It was then imported into statistical software (SPSS v24, IBM Corp., NY) and also into a relational database (Microsoft SQL Server 2012). SPSS was used to generate basic descriptive statistics to explore broad demographics of patient (age, sex) and referrer profession. Business data analytics software (Power BI, Microsoft Corp.) was used to analyse the required data from the database and display it in a variety of interactive charts allowing filtering of the data to fit the requirements of the objectives. This allowed region specific, sex-specific and age-specific data to be obtained fulfilling objectives analysing:

- Referrer characteristics (such as locality, profession-specific frequency of referrals),
- Referral characteristics (such as region of interest for MSK US scan, clinical indications for referrals including time since injury, region and structure of interest, and a clinical query)
- MSK US report characteristics (such as sonographer clinical indication, scanned region, scanning protocol, opinion/s of sonographer, need for further investigation).

## Level of agreement calculation

The number of queries associated with each referral was recorded. This was compared to the corresponding sonographer opinions. The number of queries that matched the opinion of the sonographer were recorded. The query and opinion were matched at the discretion of the researcher.

An example of a referrer's query for two queries would be: “? *subdeltoid bursitis*; and ?*rotator cuff pathology*”. The opinions that resulted from the scan in responses to this query might include impingement, subdeltoid bursitis, and acromioclavicular arthritis (i.e. 3 opinions). This would be a match of only one out of three as only bursitis is common between both the referrer and sonographer.



## CHAPTER 4 RESULTS

Chapter 4 is structured in three sections. The first demonstrates the high level of reliability between the principal researcher and the assistant in extracting raw data from clinical records. The following two sections divide the results obtained from the referral request and the sonography report. The most commonly referred for regions have been analysed in greater detail. These regions are the shoulder, knee and Calf/Ankle/Foot (CAF) groups.

### **Section 1: Reliability study**

For each case there was a total of 206 cells of information to be extracted. Due to the extent of the information it was not feasible to calculate chance corrected reliability statistics such as kappa. Therefore, percentage agreement was used to represent reliability. However, it is noted that this can result in inflated levels of agreement.

Inconsistencies only occurred in free-text 'Region of interest' (both for intra-rater and inter-rater), 'Clinical indication' (both for intra-rater and inter-rater), 'Referrer query' (intra-rater only), and 'Sonographer region of interest'.

#### *Intra-rater reliability*

Of the 412 cells compared between ratings only 7 (3.4%) were different, resulting in a 96.6% rate of agreement intra-rater reliability.

#### *Inter-rater reliability*

Of the 412 cells compared between the two raters only 6 (2.9%) were different, resulting in a 97.1% rate of agreement between researchers.

## Section 2: Results obtained from referral request

### Patient demographics

Patients were evenly distributed male (n=494) to female (n=496) with ages ranging from 7-87 years of age (see Figures 1.1-1-3 to these this data according to common regions). No age limits were defined as the study was exploratory, hence the whole population that was referred to for MSK US was included.

### Shoulder

There were 289 shoulder referrals, 139 females and 149 males (see Figure 1.1-1).

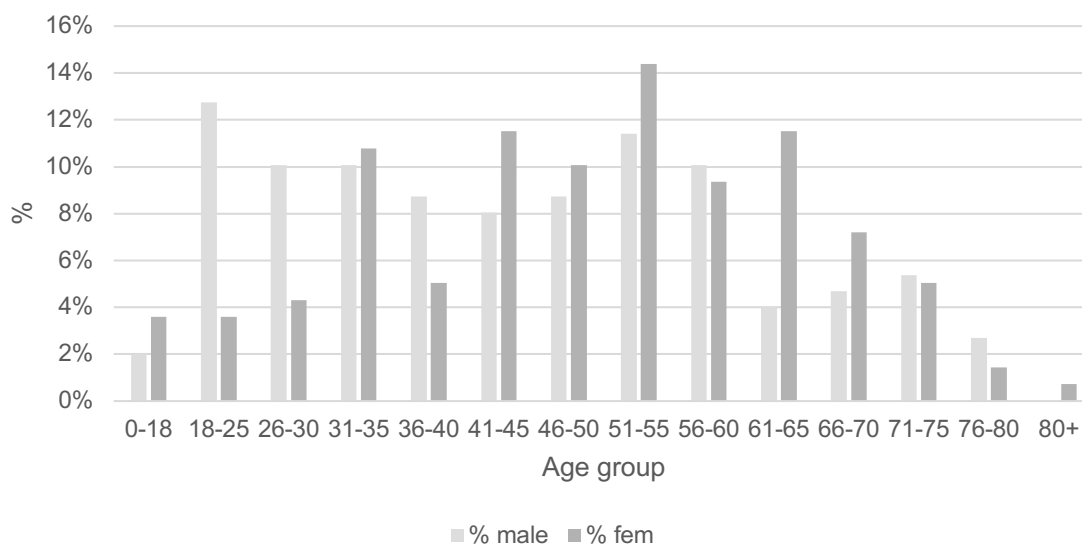


FIGURE 0-1. PROPORTION OF MALES AND FEMALES WITHIN SHOULDER REFERRALS SAMPLE

## *Knee*

There were 163 knee referrals, 82 females and 81 males (see Figure 1.1-2).

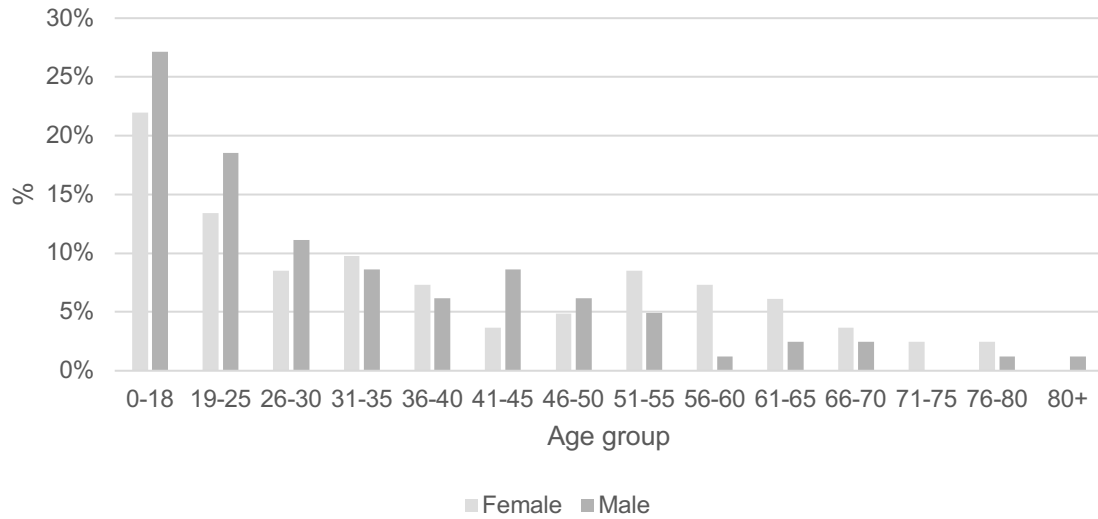


FIGURE 0-2. PROPORTION OF MALES AND FEMALES WITHIN KNEE REFERRALS SAMPLE

## *Calf/Ankle/Foot*

There were 317 CAF referrals, 189 females and 128 males (see Figure 1.1-3).

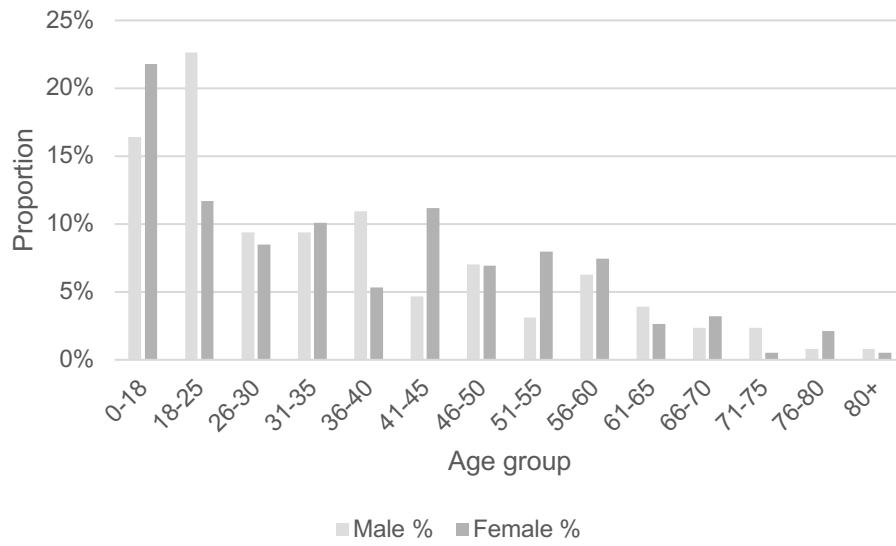


FIGURE 0-3. PROPORTION OF MALES AND FEMALES WITHIN CALF/ANKLE/FOOT REFERRALS SAMPLE

## Referrer demographics

In 2016 there were 166 unique referrers within the sample. All referrals came from the Auckland region. The sonographer for this case study operates from 4 locations in Auckland. The geographical distribution of these referrals ranged from Westmere to Whangarei (160km by driving distance) with most referrals between East Tamaki and Huapai (45km by driving distance).

A random sample of 1000 cases were identified using a proportional approach from each month out of a possible 3354 referrals for the calendar year 2016 (see Figure 1.1-4). The total of 3354 included steroid referrals which made up approximately 10% of the total but these cases were excluded from this study.

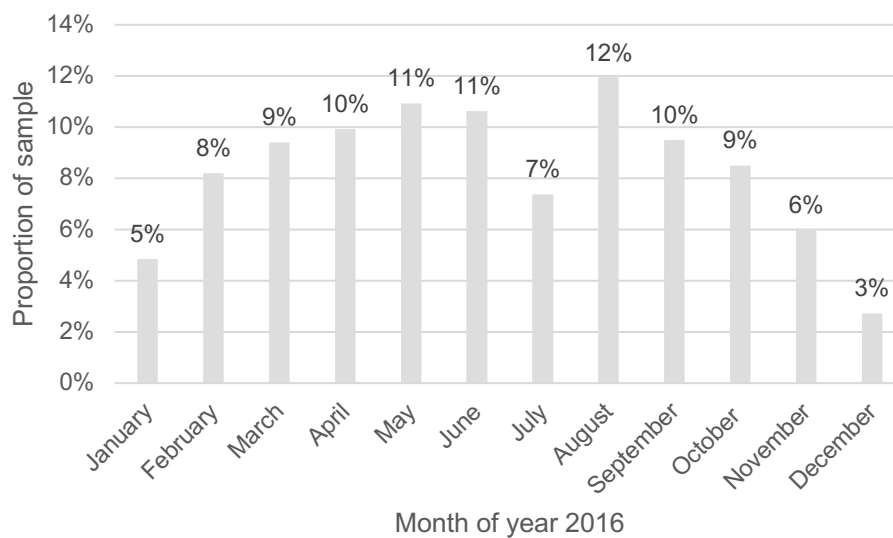


FIGURE 0-4. DISTRIBUTION OF SAMPLE REFERRALS ACROSS THE YEAR OF 2016 (EACH MONTH WAS PROPORTIONAL TO ACTUAL NUMBER OF CASES)

## Referrals per year by profession

The most common referring profession was physiotherapy, constituting approximately 80% of all referrals for this MSK US practice. The remaining 20% arose from four other professions: osteopathy, podiatry, and medical doctors (in descending order) (see Table 2).

The median number of referrals from each unique referrer for a given profession was calculated (see Table 2). There was a significant difference (Mann-Whitney U 1379.50,  $z=-2.338$ ,  $p=0.019$ ) in the median number of referrals made by physiotherapists (mdn=2.5, IQR= 6) compared to osteopaths (mdn=2.0, IQR=2).

TABLE 2. MEDIAN NUMBER OF REFERRALS PER YEAR BY PROFESSION

Profession	n	Median	Minimum	Maximum	Interquartile Range
Physiotherapist	35	2.5	1	42	6
Osteopath	106	2	1	11	2
Podiatrist	5	8	2	23	12
Doctor	22	1	1	12	0

## Pre-determined text- Region of interest

A series of regions were pre-printed on the referral form as a check-box for the referrer to indicate the body region of clinical interest. Of the 1000 referrals, 80% region check-boxes were completed. The most common requested body region was shoulder (27%) followed by knee (16%) and ankle (15%).

## Free-text box

In addition to check-boxes, the referral form also provided the option to write free-text describing information necessary to support the referral. This information comprises the 'Referrer Text Region', 'Referrer Clinical Indication', 'Time Since Injury', and 'Referrer Query'.

### *Referrer text region of interest*

Only three referrals did not indicate a region in the text area on the referral request. The 'Referrer Text Region' responses were 60% lower limb, 38% upper limb, and 2% axial. This was further divided into the categories seen in Table 3.

TABLE 3. PROPORTION OF REFERRER TEXT REGIONS

<b>Axial</b>	
Cervical	1%
Thoracic	0%
Lumbar/sacral	1%
Rib	1%
Abdomen	0%
<b>Lower Limb</b>	
Ankle	15%
Foot	8%
Anterior thigh	2%
Calf	7%
Fore foot	1%
Hind foot	2%
Hip	5%
Knee	15%
Lateral Thigh	0%
Medial Thigh	0%
Mid foot	0%
Planter foot	0%
Posterior thigh	3%
Shin	1%
<b>Upper Limb</b>	
Anterior arm	0%
Carpals/Wrist	3%
Elbow	5%
Hand	3%
Posterior arm	0%
Shoulder	26%



### Time since injury

Only 27% of referrals provided a time since injury (female n=144, 28.9% and male n=128, 25.9%). Time since injury ranged from the week of injury (0 weeks) to greater than a year (53 weeks) (see Figure 1.1-5). The median time since injury between date of injury and scanning date for male and female was the same, 4 weeks (male IQR 10, female IQR 6). This was further investigated by region. There was not a significant difference (see table 4) for time since injury between male and females for shoulder, knee or CAF groups.

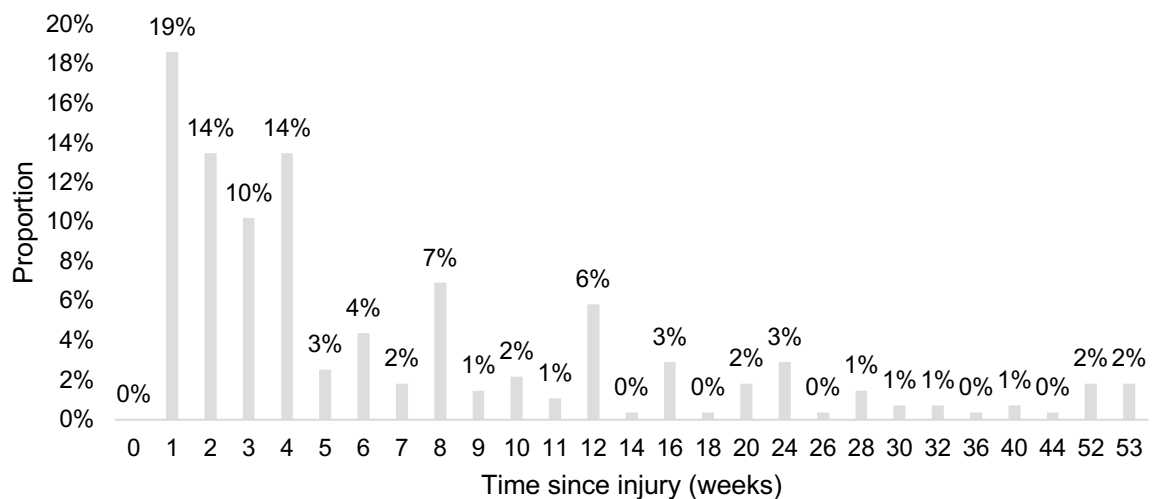


FIGURE 0-5. PROPORTION OF REFERRALS ACCORDING TO TIME SINCE INJURY(WEEKS)

TABLE 4. DESCRIPTIVE CHARACTERISTICS OF TIME SINCE INJURY(WEEKS) DATA ACCORDING TO MALE AND FEMALE GROUPS

	Gender	Median	Minimum	Maximum	Interquartile Range	Mann-Whitney U	Wilcoxon W	z	p.
Overall (all regions)	Male	4	0	53	9	9772.5	18683.5	-0.004	0.996
	Female	4	0	53	8				
Shoulder	Male	4	1	53	10	762	1465	-0.975	0.330
	Female	4	0	53	6				
Knee	Male	4.5	1	30	8.5	159	412	-0.507	0.612
	Female	3	0	40	6.25				
Calf/Ankle/Foot	Male	2	0	52	6	749.5	1245	-1.178	0.239
	Female	4	0	53	12.5				

### *Clinical indication for referral*

Referrers wrote a maximum of 5 clinical indications per referral. These clinical indications were what the referrer deemed to be important in justifying the MSK US referral. Clinical indications generally included 'location of pain', 'mechanism of injury', 'positive orthopaedic tests', and 'history' (hx) of injury'. The majority (95%) of referrers gave at least one clinical indication, although 5% of referrals included no clinical indication.

The most common clinical indications were 'pain at site' (site being a listed anatomical structure such as '*supraspinatus*'), 'MOI-specific movement injury' (this included movements that were unique such as '*rolled ankle*'), 'pain in region' (e.g. anatomical region such as '*shoulder*'), 'MOI-fall', and 'no clinical indication provided'. The 20 most frequently recorded clinical indications are displayed in Figure 1.1-6.

The category of 'Clinical Indications' was further divided into Method of Injury (MOI) MOI-sport and MOI-non-sport (see Figure 1.1-8-10). Overall, the proportion of referrers that provided a MOI was 32%. The most common sports that were being participated in at the time of injury were rugby and running (both 20% of MOI-Sport) and football (soccer) (10% of MOI-Sport) (see Figure 1.1-9).

Of the MOI-non-sport the most common were 'specific movement injury' (43%) (this was any referral that described the movement which created injury such as '*rolled ankle*') and 'fall' (29%). These two MOIs were most common for all categories; overall, shoulder, knee, CAF. The third most common were lifting injuries (10%) (such as at the gym or placing an object in an overhead cupboard), and collision/impact (10%) (see Figures 1.1-11,13,15). As a MOI, collision or impact was further classified by sport. The majority were rugby (36%), football (12%) and other sports (7%). In the case of rugby and football, tackling injuries were included in this category (see Figure 1.1-9).

The overall category was further divided into signs. Overall, 74% of referrers included clinical signs. The most common signs were 'positive orthopaedic tests' performed, 'history of injury', 'signs of inflammation', and 'other imaging previously completed'. When signs were investigated by region, orthopaedic testing was the most commonly written as a clinical indication for shoulder (9%), with other groups being 4% for knee and 5% for CAF. Signs of inflammation was the most common 'sign' for the CAF group (7%), with other groups showing 4% for knee and not appearing the in most common for shoulder.

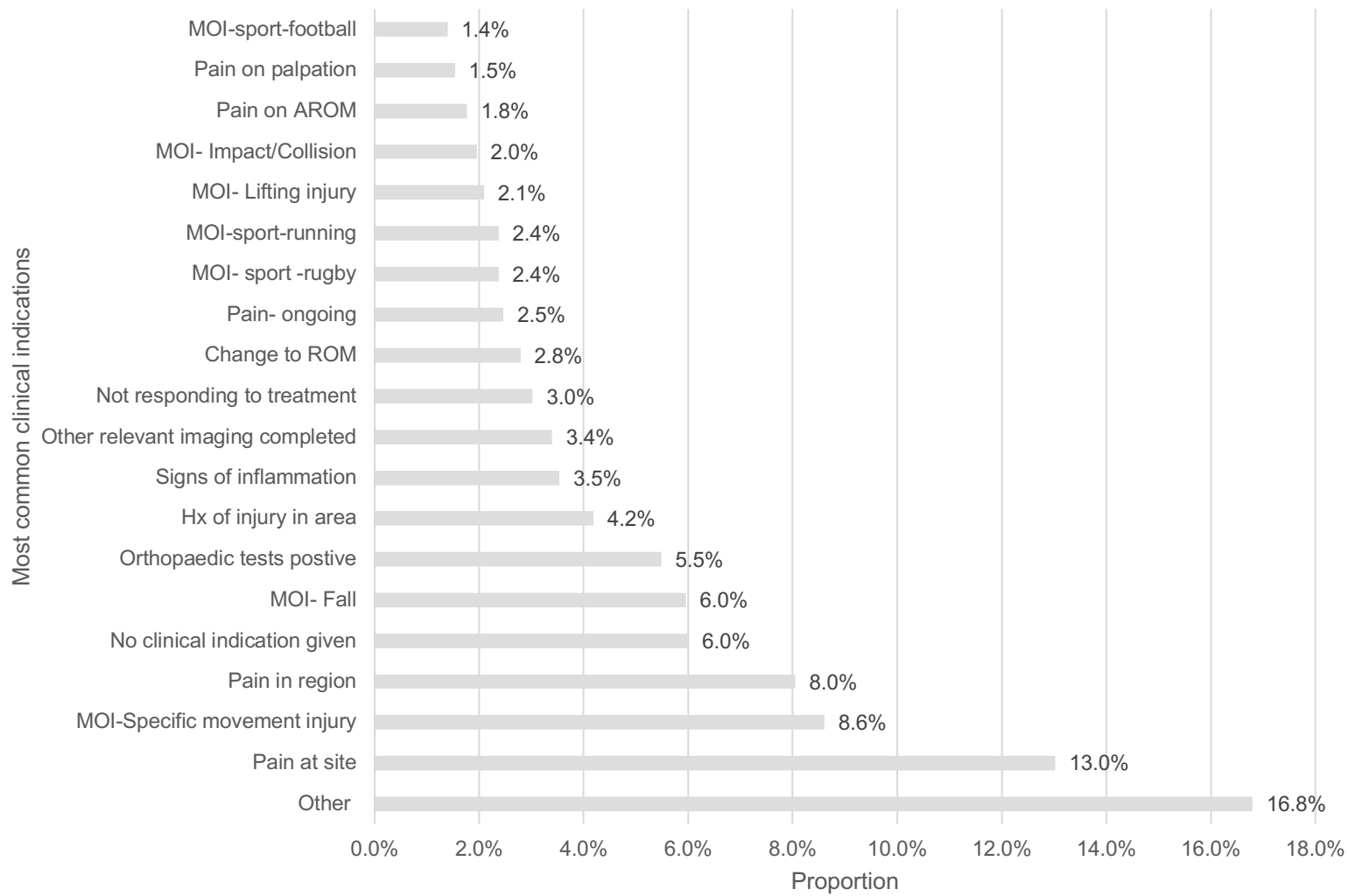


FIGURE 0-6. THE MOST COMMON CLINICAL INDICATIONS OVERALL

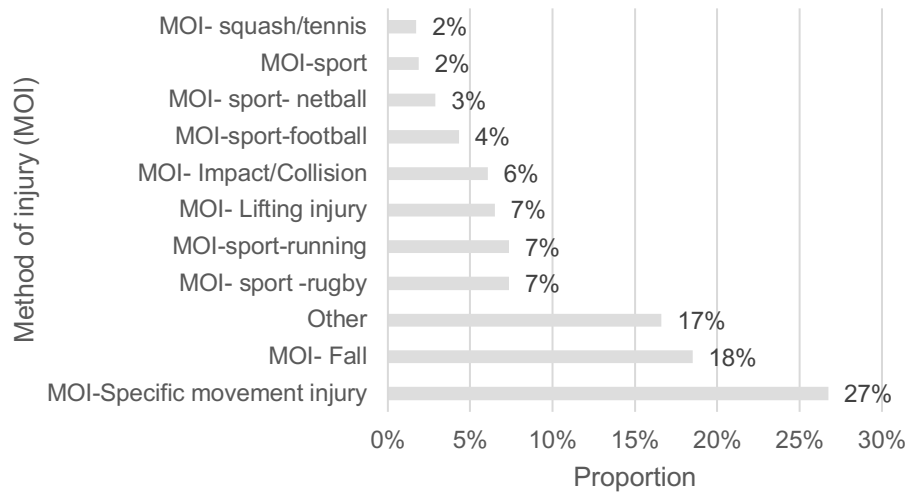


FIGURE 0-8. MOST COMMON MECHANISMS OF INJURY

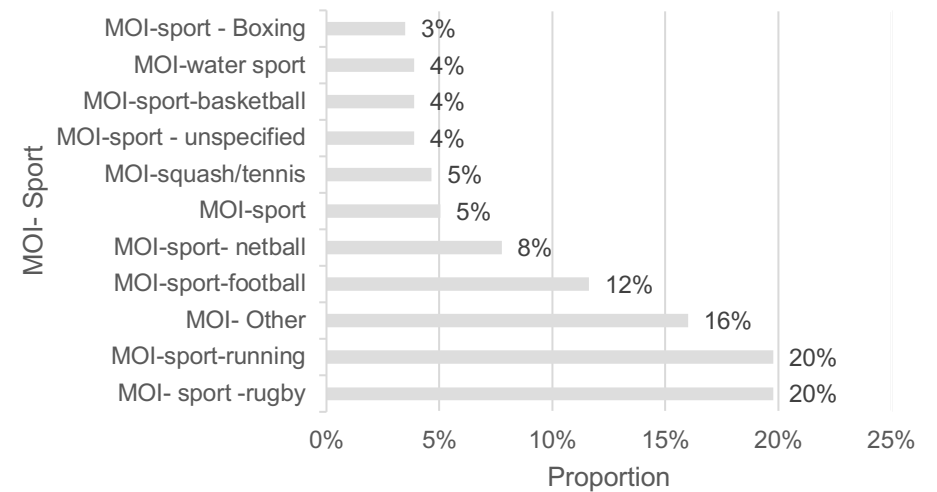


FIGURE 0-9. MOST COMMON MECHANISMS OF INJURY -SPORT

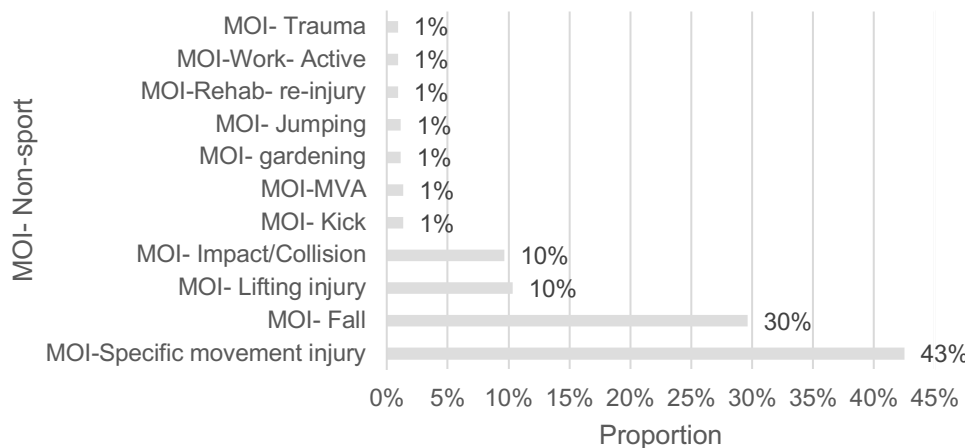


FIGURE 0-10 MOST COMMON MECHANISMS OF INJURY- NON-SPORT

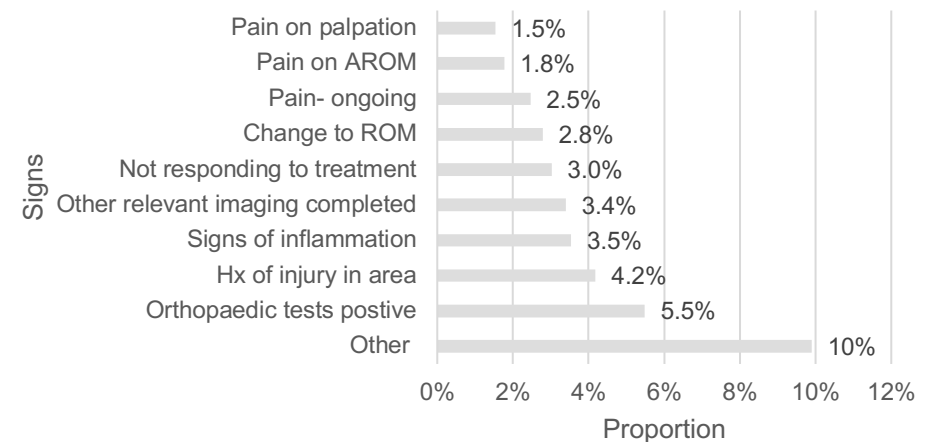


FIGURE 0-7. MOST COMMON CLINICAL INDICATIONS- SIGNS

## SHOULDER

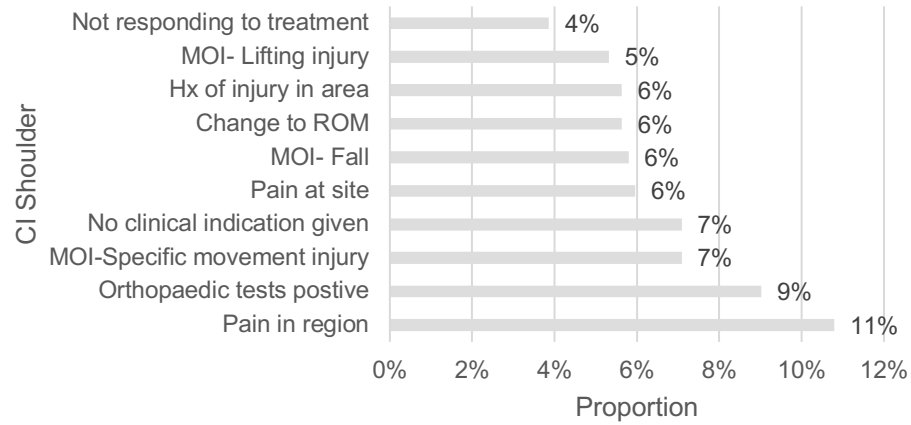


FIGURE 0-12. MOST COMMON CLINICAL INDICATIONS FOR SHOULDER

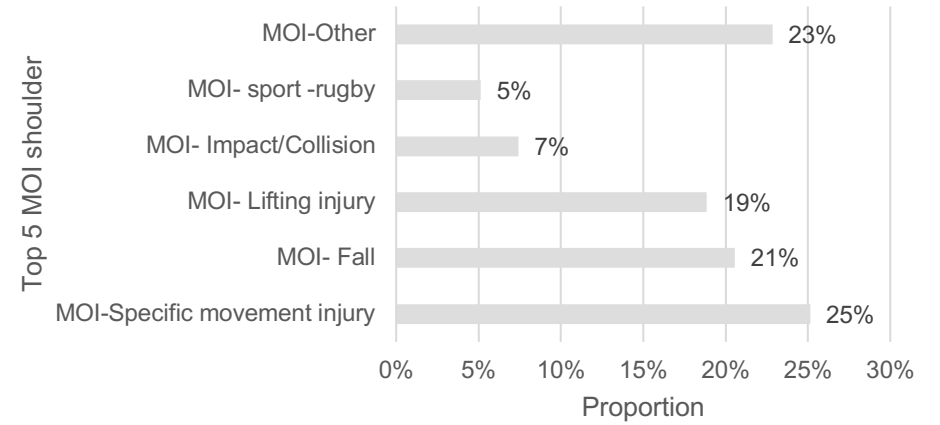


FIGURE 0-11. MOST COMMON MECHANISMS OF INJURY FOR SHOULDER

KNEE

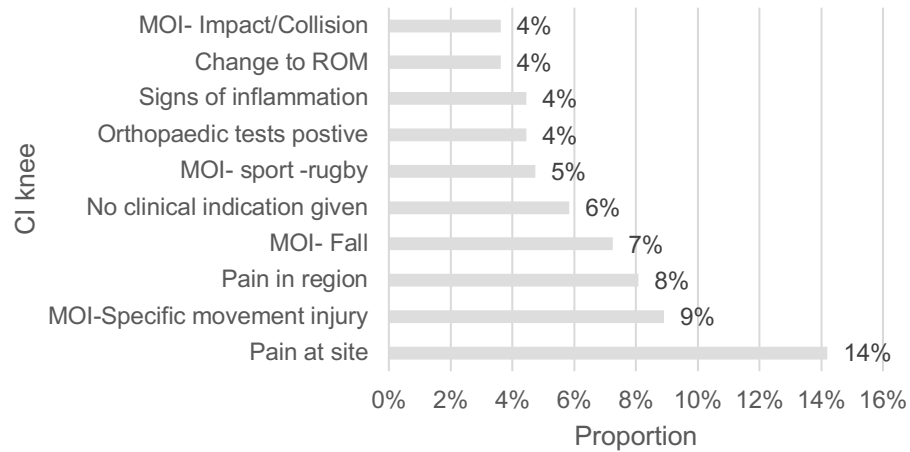


FIGURE 0-14. MOST COMMON CLINICAL INDICATIONS FOR KNEE

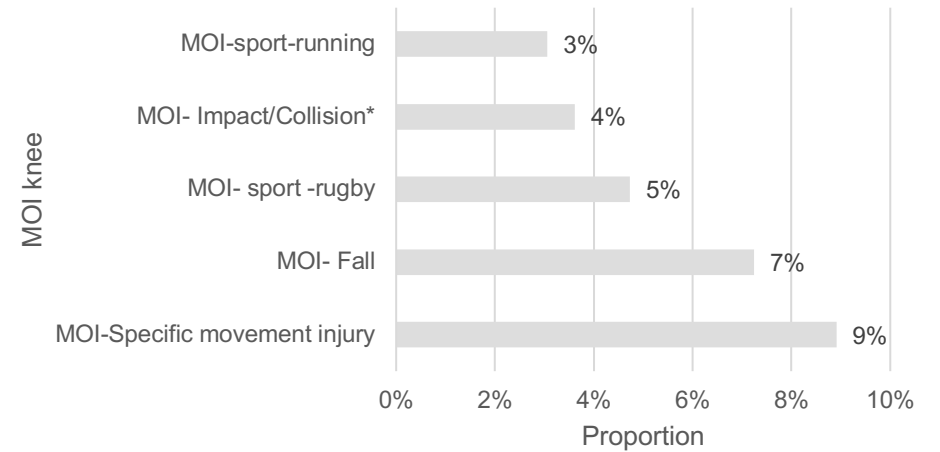


FIGURE 0-13. MOST COMMON MECHANISMS OF INJURY FOR KNEE

CALF/ANKLE/FOOT

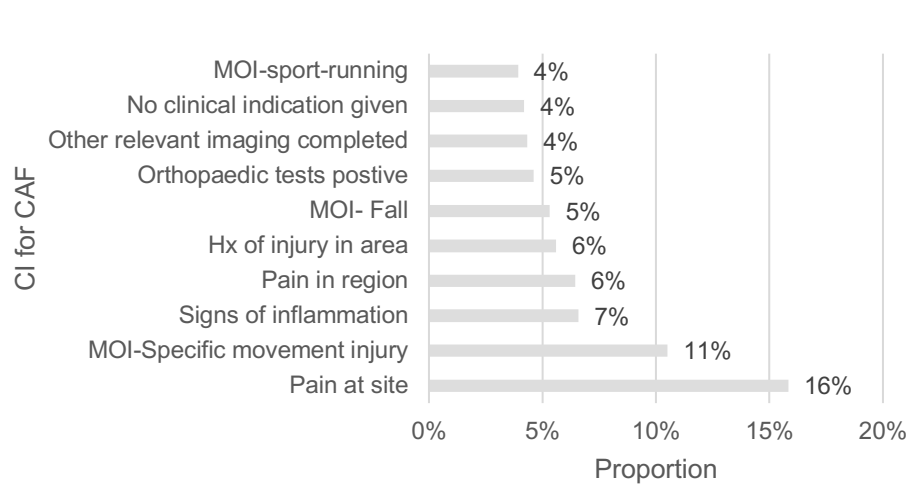


FIGURE 0-16. MOST COMMON CLINICAL INDICATIONS FOR CAF

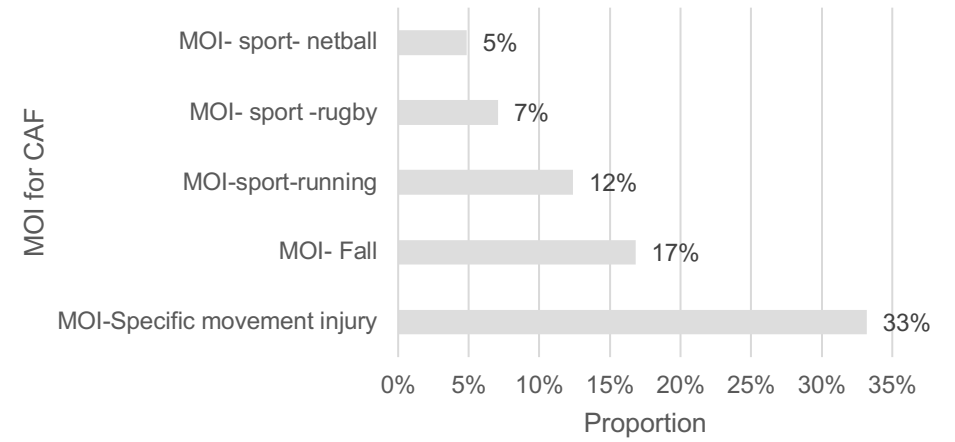


FIGURE 0-15. MOST COMMON MECHANISMS OF JURY FOR CAF



### *Conditions queried by referrer*

For each referral, a maximum of four separate queries for conditions were extracted. These were all included in one data set. Overall, 35% of referrals did not include a query. The median number of queries per referral was 1 (IQR=2). Figure 1.1-17 demonstrates the breadth of queries requested by referrers. The key conditions for which MSK practitioners referred were subdeltoid bursitis (8%) and rotator cuff disorders (9%) (see Figure 1.1-17). Also, amongst the most common results was ‘no query’ (8%) and ‘query any abnormalities’ (7%). These were referrals that did not pose a specific clinical question and included those who listed anatomical structures without any indication of their clinical reasoning (i.e. whether they were seeking imaging to ‘rule in’ or ‘out’ a diagnostic hypothesis). Most referrals included less than two queries for the broader regions as demonstrated in Table 5.

The broad regions were further investigated for queries under Shoulder, Knee, Calf/Ankle/Foot categories (Figures 1.1-18-23). These also show large ‘other’ categories also demonstrating the breadth of queries within the body region data. The ‘other’ categories consist of all the remaining unique queries that were not included in the top portions. The most common shoulder queries were the same for males and females, with the addition of supraspinatus tears in females (see Figures 1.1-18-19). For the knee, referrer queries about the presence of patellar tendinitis, synovial cysts, and lateral collateral ligament problems were more frequent in females than males, whereas knee bursitis was more common in males (see Figures 1.1-20-21). The CAF group had a greater variety given that it encompasses several regions. In males, the most common clinical query was a talofibular ligament tear, whereas in females the most common was plantar fasciitis (see Figures 1.1-22-23).

TABLE 5. PROPORTION OF NUMBER OF QUERIES FOR BROAD REGIONS

		Number of Queries										Total per region
		0		1		2		3		4		
	Axial	15	4%	8	2%	5	2%	0	0%	0	0%	28
Referrer	Lower Limb	257	66%	243	60%	119	47%	34	67%	1	100%	654
Text	Upper Limb	119	30%	152	38%	128	51%	17	33%	0	0%	416
Region	Total number of queries	391	100%	404	100%	252	100%	51	100%	1	100%	

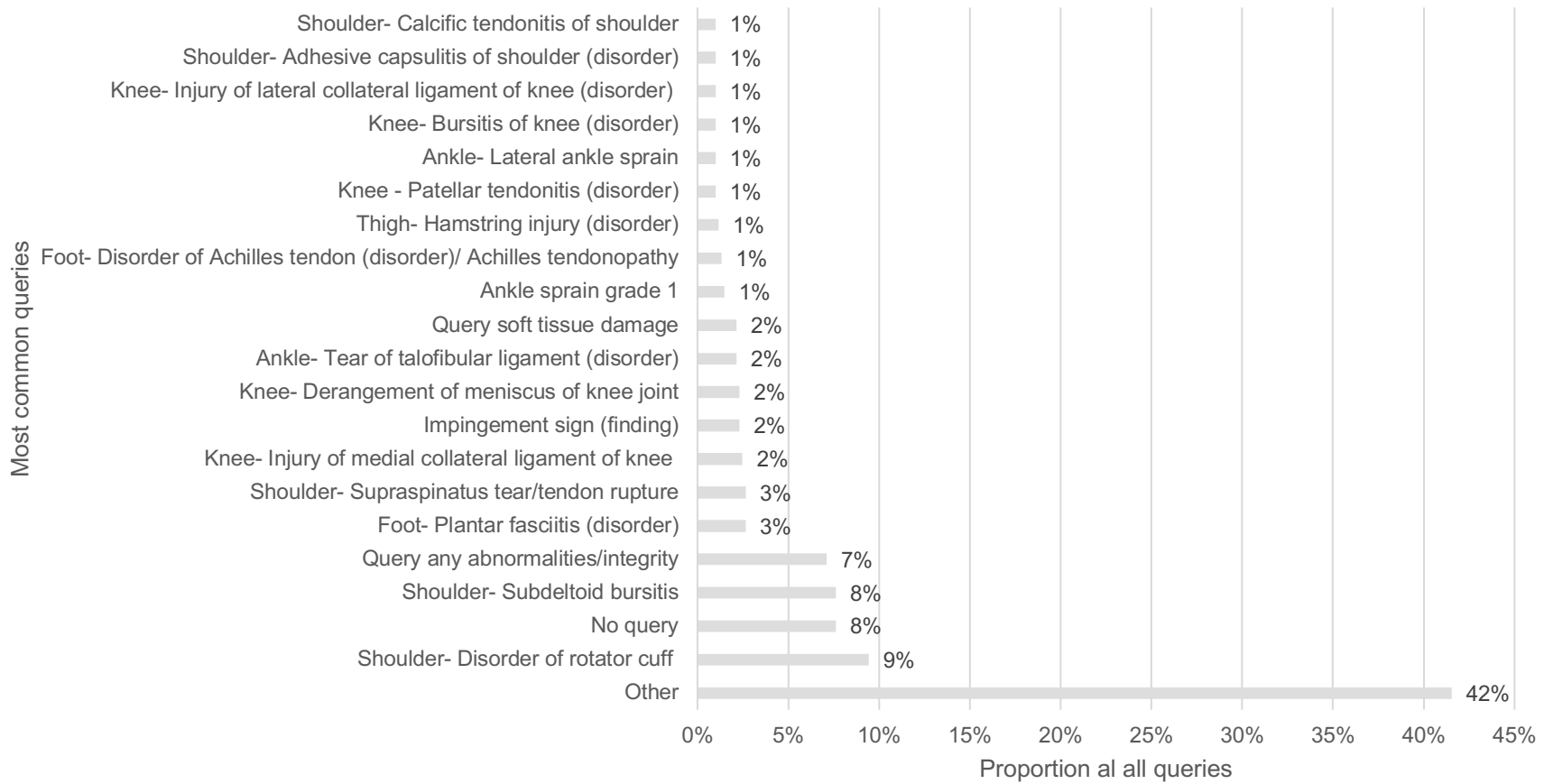


Figure 0-17. Most common queries of referrers

### Regional queries by Gender

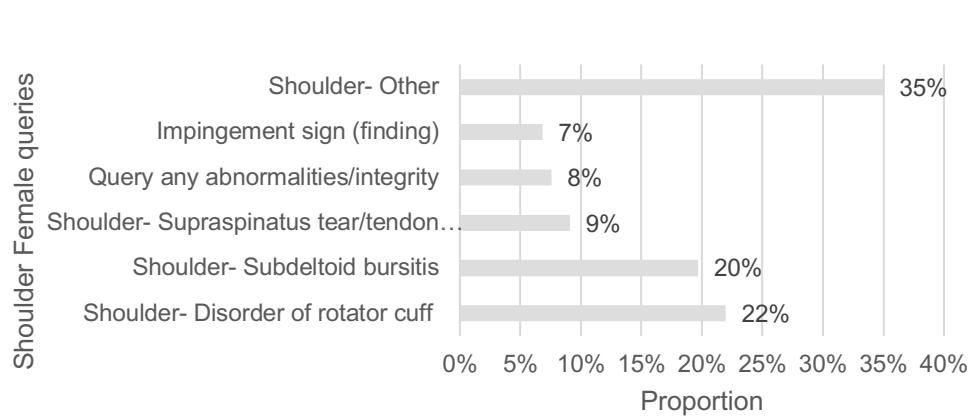


FIGURE 0-18. FEMALE SHOULDER QUERIES

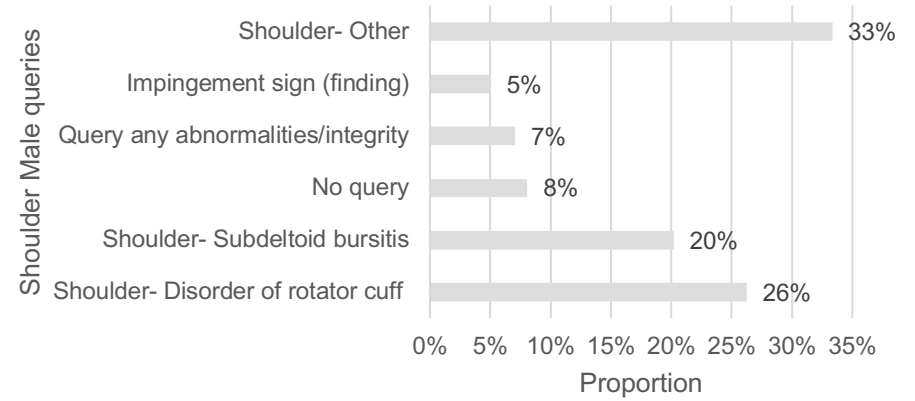


FIGURE 0-19. MALE SHOULDER QUERIES

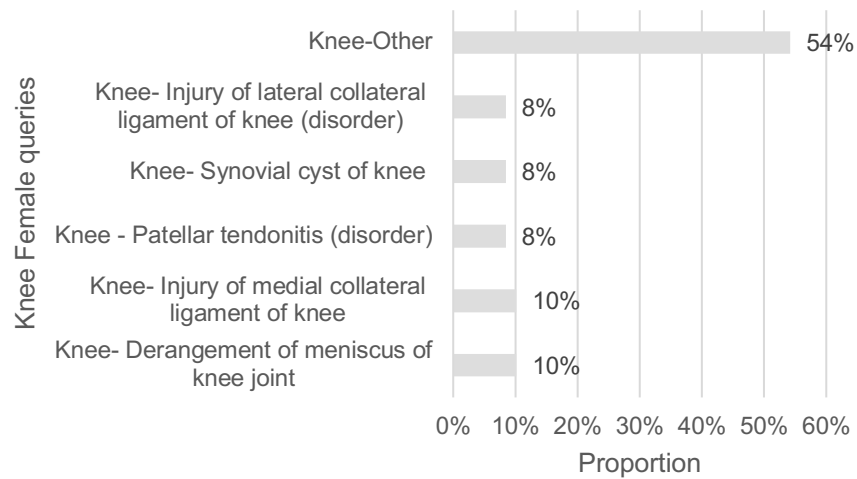


FIGURE 0-20. FEMALE KNEE QUERIES

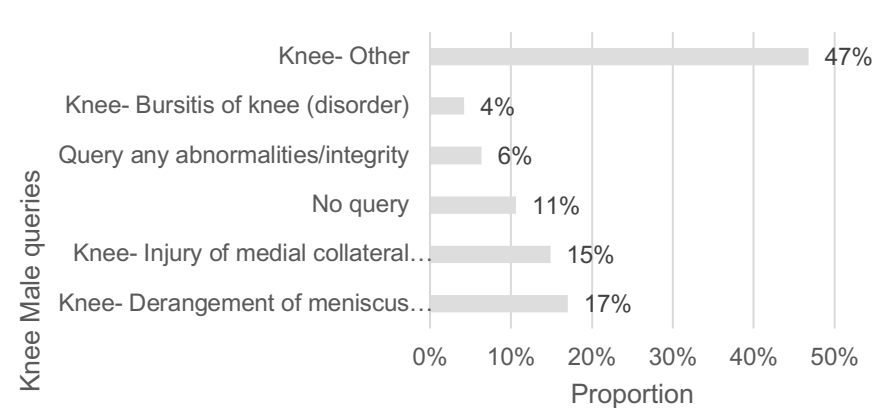


FIGURE 0-21. MALE KNEE QUERIES

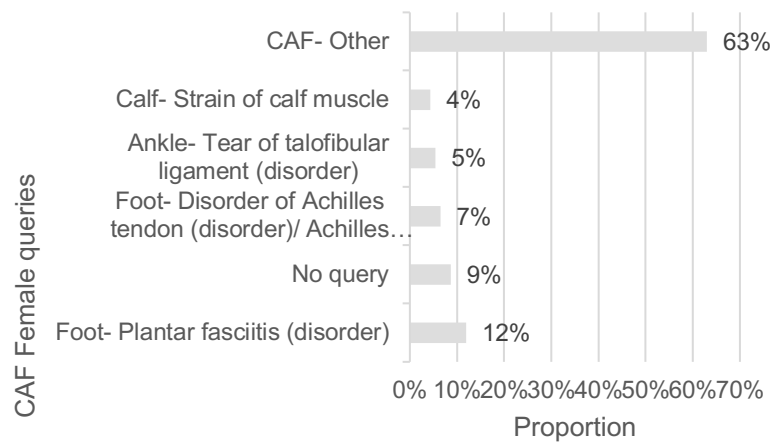


FIGURE 0-182. FEMALE CAF QUERIES

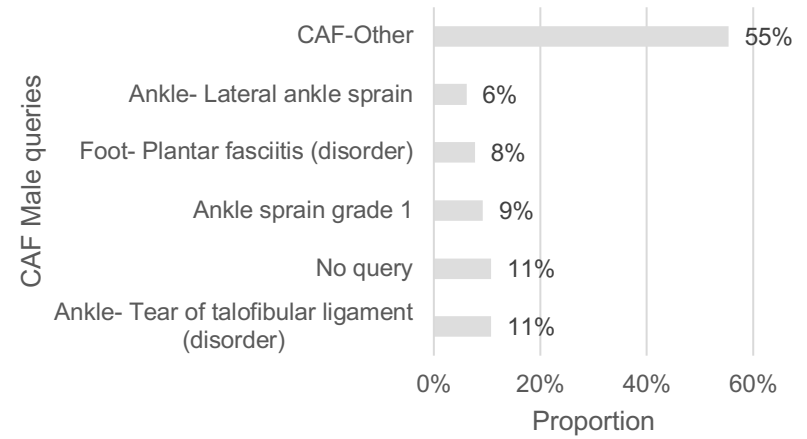


FIGURE 0-193. MALE CAF QUERIES

## Section 3: Results obtained from ultrasound report

### Sonographer clinical indications

Sonographer clinical indications include the information the sonographer routinely added to the ultrasound report based on history recorded by the sonographer at the time of consultation. In this case study the sonographer routinely undertook their own short case history before scanning the patient. The most common information added was a history of injury in the area, a description of injury event, and the site of injury (see Figure 2.2-1).

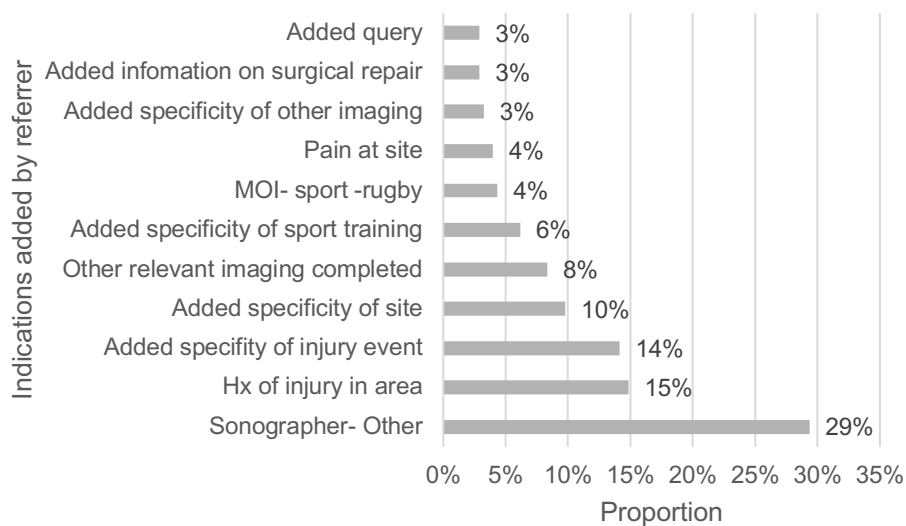


FIGURE 0-1. CLINICAL INDICATIONS ADDED BY SONOGRAPHER

## Scanning protocols

This category examined the frequency of scanning protocols<sup>4</sup> used by the sonographer for each region. Further information on what structures were examined per region can be seen in [Appendix D](#). Pre-determined scanning protocols were used in almost 70% of scans. The most common protocols for this align with the most common check-box regions. These are shoulder (32.1%), knee (18.8%) and ankle (16.5%). The remaining 30% consisted of reports that did not contain a scanning protocol.

---

<sup>4</sup> Scanning protocols were retrieved from the sonographer's report. They included a generic list of structures routinely scanned for a given region. For more details see Appendix D.

## Opinion of sonographer

The number of unique opinions is displayed in Table 6. It shows that in this sample of 1000 referrals there were over 300 different opinions resulting from scans. Shoulder had the highest number of opinions (mean=2.42) per shoulder scan (n=698 opinions). Whereas knee and CAF were lower at 1.4 (n=232) and 1.6 (n=525) opinions per referral respectively. A greater number of opinions were displayed for the CAF group because it encompasses multiple areas.

Overall, the shoulder region had the lowest frequency of “No cause for queried area of pain identified” (3%) while knee and CAF had 13% and 19% respectively (see Figures 2.2-2-4).

TABLE 6. OPINION TALLY BY REGION

		Count	Unique opinions	Frequency of opinions	Average number of opinions per referral
Upper Extremity	Overall	404	89	863	2.14
	Shoulder	289	49	698	2.42
Lower Extremity	Overall	581	81	882	1.52
	Knee	165	35	232	1.41
	CAF	320	81	525	1.64
Axial		24	14	32	1.33
Total		1000	349	3232	3.23



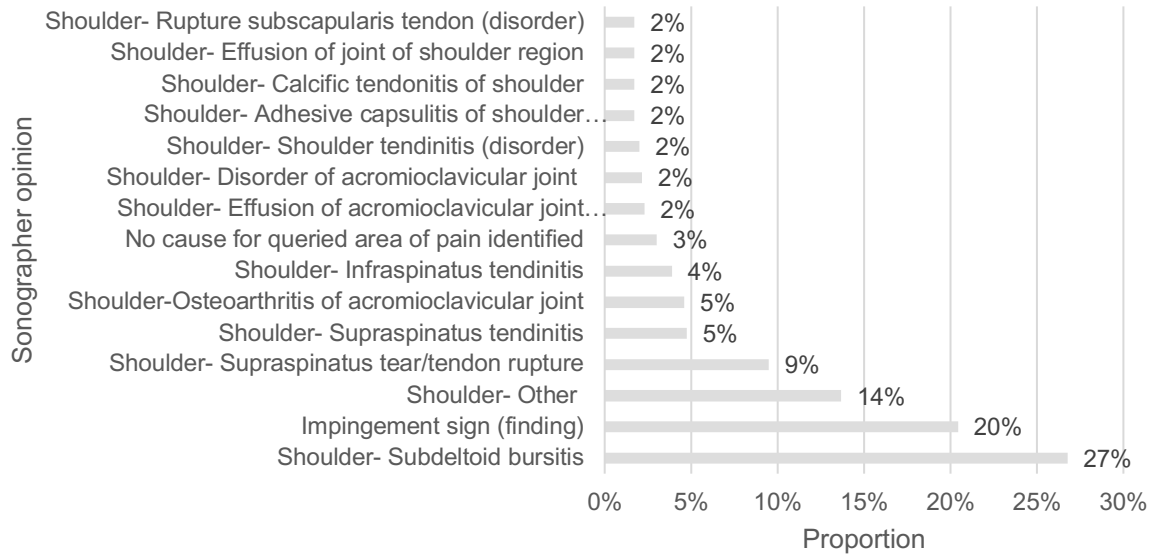


FIGURE 0-2. SONOGRAPHER OPINIONS FOR SHOULDER REGION

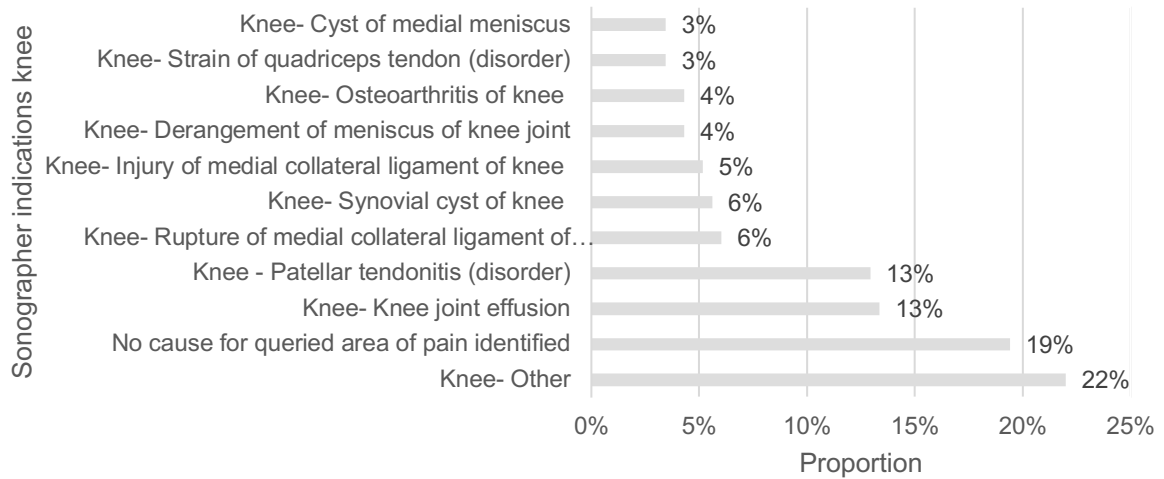


FIGURE 0-3. SONOGRAPHER OPINION FOR KNEE REGION

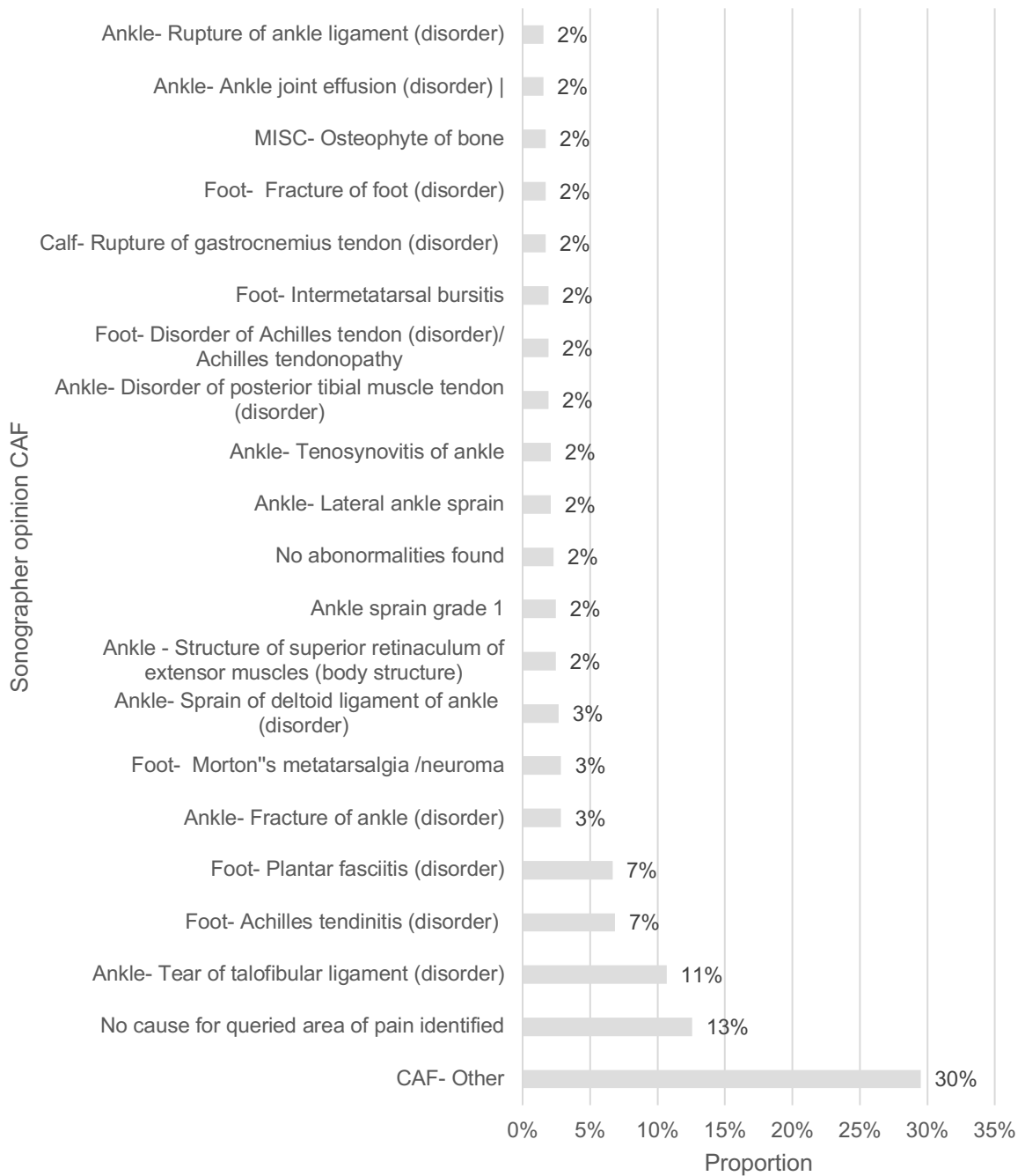


FIGURE 0-4. SONOGRAPHER OPINION FOR CAF OPINIONS

## Agreement between referrer query and sonographer opinion

There were 355 referrals that made no query. Of the remaining 645 referrals, those that made a lower number of queries generally had a higher level of agreement between their own queries and sonographer opinions. For example, approximately half of those who made one or two queries would have at least one match with the sonographer. Whereas, a referrer who made three queries only matched all three with the sonographer opinions in only 7% of this sample.

TABLE 7. LEVEL OF AGREEANCE BETWEEN REFERRER AND SONOGRAPHER MEASURED BY NUMBER OF QUERIES THAT MATCHED WITH THE CORRESPONDING OPINIONS

Number of queries made by referrer	Number of queries that matched with an opinion	Total number of queries that matched with an opinion	Proportion of queries that matched with an opinion	Total number of queries
0	0	355	100%	355
1	0	206	55%	377
	1	171	45%	
2	0	101	45%	223
	1	98	44%	
	2	24	11%	
3	0	10	24%	42
	1	16	38%	
	2	13	31%	
	3	3	7%	
4	0	1	100%	1

## CHAPTER 5 DISCUSSION

This study investigated characteristics of requests and sonography reports for musculoskeletal ultrasound (MSK US) from musculoskeletal (MSK) practitioners to one diagnostic ultrasound imaging practitioner within the Auckland region. In total, a sample of 1000 referral requests and associated sonography reports were analysed to retrieve descriptive information. This included describing demographic characteristics of patients and referrers, categorising pre-determined ('checkbox' fields) and free-text fields used by referrers to indicate reasoning for the referral, and finally to categorise and quantify the information published in the sonographer's formal report. Although this study is of a single sonography practitioner, the findings offer an insight into the elements currently included in referrals and the corresponding diagnostic reports.

There appears to be only one other study reporting referral patterns from MSK practitioners for diagnostic sonography (Roberts, Winner, Littlejohn, et al., 2006). Other previous studies related to sonography and MSK practice have largely focused on how physiotherapists are using MSK US for non-diagnostic applications (i.e. RUSI) within their own practices (Ellis et al., 2018; Jedrzejczak & Chipchase, 2008; S McKiernan et al., 2011; Roberts, Winner, & Littlejohn, 2006). Three studies identified barriers to the usage of MSK US within a NZ and Australian context (Ellis et al., 2018; Jedrzejczak & Chipchase, 2008; S McKiernan et al., 2011). However, it is unclear whether these studies were exploring RUSI or DUSI ultrasound, but it is most likely they are referring to RUSI, as DUSI training requires tertiary education and registration as a sonographer (The University of Auckland, 2017), making them less relevant to this study. Regardless, barriers identified in these studies are of general relevance and included access both to education and training (Ellis et al., 2018; Jedrzejczak & Chipchase, 2008; S McKiernan et al., 2011). One study investigated the use of protocols and procedures when referring for MSK US (Roberts, Winner, & Littlejohn, 2006). Roberts et al (2006) conducted interviews with 52 physiotherapists based in Wellington, NZ and asked them whether they were aware of imaging protocols, and if they used them when referring for either MSK US or plain film X-ray. At the time, not all physiotherapists knew they could refer for MSK US. This study examined plain film X-ray in more depth than MSK US and found that when referring just over half of the physiotherapists were using the Ottawa rules for referral of ankle injury (Stiell et al., 1994), and less than 10% were referring for imaging consistent with the ACC guidelines (Roberts, Winner, & Littlejohn, 2006). This study was published in 2006, so the number of ACC guidelines was lower perhaps contributing to the low level of awareness reported. None of the four studies above reported data extracted from referral requests from MSK practitioners, hence it appears the current study may

be the first of its type and reports aspects of the referral process for MSK US that have not previously been investigated.

The MSK US sonographer in this case study operates from four locations in the Auckland region: the main site being an osteopathy teaching clinic in Auckland. The other three locations are in central and north Auckland, all within 12km driving distance of each other.

Referrals were made by many referrers; whose patients travel across a geographic zone of more than 45 km. This shows the large distance MSK practitioners refer across and the distance patients are willing to travel for this service. This could suggest a shortage in sonographers specialised in MSK DUSI.

All analysed cases had corresponding ACC claims. Even though only one practice was examined, a request made to ACC for data indicates that this practice accounted for ~8% of the MSK sonography services claimed in the Auckland region in 2016 (Piuila-Afitu, 2018c). Previous studies evaluating MSK US use in NZ have not included ACC-related questions in their surveys, nor provided descriptive statistics about the patients and referrers involved in the referral for MSK US (Ellis et al., 2018; Roberts, Winner, & Littlejohn, 2006).

Despite the sonographers' location within an osteopathy teaching clinic the largest referring profession was physiotherapy. Osteopaths, podiatrists and medical doctors constituted less than a quarter of referrals overall. There was a significant difference between the number of referrals per unique referrer for the two largest referring groups (physiotherapy and osteopathy). Physiotherapy had roughly 25% more referrals per unique referrer. This might suggest that there is an under-recognition or lack of awareness of the utility of MSK US amongst osteopaths. Studies investigated reasons for low rates of MSK US use within the RUSI context. These included a lack of access and training, and limited knowledge generally about MSK US (Chipchase & Jedrzejczak, 2006; Ellis et al., 2018; S McKiernan et al., 2011). Although these studies pertained to RUSI applications, these findings provide some general insight into sonographer and MSK practitioner nexus and indicate further education and awareness would be beneficial.

In this study, the number of referrals was grouped according to the most common body regions. These regions correspond to those that are also represented in published imaging or referral guidelines. These included the ACC soft tissue knee injuries and shoulder pain documents as well as Ottawa Knee and Ankle Guidelines (Accident Compensation Corporation, 2003, 2011; Stiell et al., 1994; Yao & Haque, 2012). These also correspond to the regions with high numbers of claims from ACC (Piuila-Afitu, 2018b, 2018c). In this study, the most commonly referred regions for MSK US were

shoulder (29%), knee (16%), calf/ankle/foot (32%). The ACC Service item for the shoulder ‘U30- US Shoulder’ constituted just under half of all MSK US claims to ACC in 2016 (Piuila-Afitu, 2018c).

Body region was noted by the referrer in two ways, firstly, by pre-determined text (‘check-boxes’) and, secondly, using a free-text field on the referral request. The check-boxes included a variety of regions a referrer could tick as the desired region for imaging. The free-text field was available to record any information the referrer thought was important for the sonographer to know. Information recorded included region of interest, time since injury, clinical indications for referral (including sport, non-sport and clinical signs) and queries for specific conditions. Almost a quarter did not fill in the pre-determined text region where as nearly all practitioners indicated region by text. This could have been because the check-boxes oversimplified the region of interest, which is what the researchers experienced when extracting data. For example, the Achilles tendon covers calf, ankle and heel (which was considered ‘hind foot’ in this research). Researchers were reliant on other information such as written region of interest or query to determine which region the referrer wanted scanned. The written information was often unclear or mismatched with the ‘check-box’ or the sonographers scanned region. This suggests the sonographer has to utilise all of the information on the referral sheet to determine which area was the most appropriate to scan rather than the ‘check-box’ alone.

Roberts et al. (2006), asked physiotherapists what information they generally included in a referral to a radiologist. Similarities were found in the free-text box in the MSK US referral requests from this study and the surveys from physiotherapists about plain film X-ray referrals. The most common elements physiotherapists said they would include were their suspected diagnosis (equivalent to queries for specific conditions) (73%), relevant history (equivalent to any information in the free-text box) (56%), mechanism of injury (the same terminology is used in this study) (65%), and relevant symptoms (equivalent to clinical signs) (38%) (Roberts, Winner, & Littlejohn, 2006). Although the physiotherapists in the study by Roberts et al (2006) stated information they would include in a plain film X-ray referral, similar proportions of information were found with regards to ultrasound in this study. Frequency of expected diagnosis or query were similar, as well as stating method of injury (Roberts, Winner, & Littlejohn, 2006). However, reporting of relevant symptoms/clinical signs was much higher at 74% (signs included everything except query abnormalities, pain in region or pain at site) this could imply that referrers are including more detail in MSK US referrals than plain film X-ray. This is likely helpful as it creates a greater clinical picture for the sonographer.

A report of “relevant history” as in Roberts et al would have likely been categorised under the Clinical Indication-Sign group. This study defined a ‘sign’ as information the referrer obtained from the patient using their expert knowledge. Signs most commonly included were orthopaedic tests, history

of injury, signs of inflammation and other imaging previously completed. The findings of orthopaedic testing was not included often in referrals. Shoulder cases had the highest volume of this clinical indication at 9%. Very few referrals indicated that the patient was not improving, or the condition was worsening (7%) which might have been expected in lieu of inflammation (3%) or positive orthopaedic testing (5%).

Of those who did indicate time since injury, most patients were referred within four weeks of their injury. While there was no significant difference between males and females, the median time for referral varied slightly between Calf/Ankle/Foot (CAF) males who had the quickest response time of 2 weeks and Knee males who had the slowest referral time of 4.5 weeks. There is an opportunity for more research in this area. The time since injury implies a stage of healing that a given tissue should be at. For example, in a calf tear, the characteristics of the wall of the haematoma created by a trauma changes over a series of months. Initially it has thin hypochoic walls until approximately 45 days following trauma when the walls start to concentrically thicken and the fluid reduces, these walls finally collapse after 5 months allowing fibrous bands to integrate with muscle fibres (Bianchi and Martinoli, 2007). A similar, more well-known example is the imaging used to review a scaphoid fracture. Continued research on the most appropriate time for imaging has led to the development of a controversial repeated scan protocol for those who have continued pain following a wrist trauma and an initially clear X-ray (Shetty, Sidharthan, Jacob, & Ramesh, 2011). This is to rule out avascular necrosis and reduce progression into a variety of complications (Shetty et al., 2011). Both examples indicate that knowledge of tissue healing times relative to a particular trauma to a region can indicate either optimal windows for referral or useful information in determining how well an injury is healing. It is this kind of information that can be used to maximise the use of MSK US as a tool if it were described in imaging guidelines and educated to MSK practitioners.

The utilisation of MSK DUSI needs to be encouraged as well as further research to improve referral efficiency and effectiveness. Jedrzejczak and Chipchase (2006) found that only a quarter of the physiotherapists they surveyed used MSK US for diagnosis (Chipchase & Jedrzejczak, 2006). This result aligns with an earlier finding by Roberts et al. (2006), who found that almost all physiotherapists wanted more education on ultrasound. The most common education needs included “when it was appropriate to refer” and “how to interpret resulting imaging” (Roberts, Winner, Littlejohn, et al., 2006). If MSK practitioners are unsure when it is appropriate to refer, it is likely that as a result, they may be under-referring. This presents an opportunity for further research to further examine the nature and patterns of referral by MSK practitioners for MSK US. Research to explore the clinical reasoning underpinning referral for MSK US, and how the clinical reports generated by sonographers might influence a referring practitioners’ management would be useful.



There appear to be no definitive guidelines available in the MSK professions regarding what information should be included in a request for MSK US. However, correspondence with the sonographer in this case study highlighted a perceived mismatch between what clinical information should, in their view, be included in the referral, compared to what was commonly included in the referral (personal communication, Scott Allen, 15 March 2018). This point can be illustrated in this study by the level of agreement between the referrers query and the sonographers' opinion. The query was included in the free-text section and was represented by a specific condition the referrer requested be investigated in the US scan. It was unclear whether the referrer wanted these 'ruled in' or 'out', although most of the referrers included a query. When referrers offered a lower number of queries, there was more likely to be a match between their query with an opinion of the sonographer. For example, those who asked three queries only matched all three with sonographer opinions in less than 10% of referrals. The inclusion of a high number of queries could represent a complex case or a higher level of clinical uncertainty. It could be argued that it is these referrals, with higher query amounts, the need for MSK US investigation is greater due to the perceived ambiguity of the case.

One sub-category was created to encompass referrals that listed a variety of structures without asking a query in relation to them, this was "Query any abnormalities". Interestingly, personal communication with the sonographer found that listing structures without an attached query was not useful for them (personal communication, Scott Allen, 15 March 2018). Instead they suggested the referrer familiarises themselves with scanning protocols (including the list of routinely scanned structures within each region) used for a given region (see [Appendix D](#)).

## **Internal validity:**

To the knowledge of the researcher there has been no other study which analyses referral requests and sonography reports in the MSK context. As such there were several challenges in establishing the procedures to extract the data from referral requests. A pilot of 10 referrals was undertaken to generate a recording spreadsheet with all categories necessary to represent the data. Naturally, as the research progressed this spreadsheet accumulated additional subcategories to most accurately describe each unique referral. A strength of the study was the adaptability of the spreadsheet which made the data entry possible.

However, there were a few categories that were difficult to classify. The first that appeared was the ambiguity of lower limb structures. Trying to classify these anatomical and functionally contiguous structures into three discrete categories (calf, ankle or foot) resulted in overly specific categories being created. These were inconsistently used due to miscommunication between researchers and the large number of cases and resulting time taken to extract data. Similarly, a major difficulty was assigning

the specific free-text to generalised subcategories. This was particularly challenging when reconciling queries and opinions with SNOMED codes. The SNOMED coding system was selected as a contemporary coding system that will soon replace the existing ICD-10 system in the NZ healthcare system. SNOMED is widely used internationally and has a large database of more specific condition codes which can be interactively searched and accessed online (Accident Compensation Corporation, 2017). However, the researchers' experience of using SNOMED in this case study was that it lacked specificity for a wide range of non-operable musculoskeletal conditions. For example, SNOMED lists 'tendinitis' not 'tendinopathies', and there were limited options for soft tissue pathologies of the hip (such as for bursitis, tendinopathies and tears of specific muscles). Another example, is that there was no specific code for plantar fascia tears. This subjective allocation of pathologies to the nearest code was difficult with two researchers extracting data. A list was made for the exceptions in attempt to keep the researchers up to date with coding decisions, however, it is possible these were inconsistently added.

Interpretation of free text was subjective in nature and therefore dependent on researcher judgement. A small reliability study was undertaken to provide some indication of the magnitude of reliability, however, a larger scale reliability study coding accuracy would be beneficial. Given the substantial number of extracted items per case (206) it was not possible to conduct formal statistical estimation of reliability coefficients such as kappa without access to more advanced statistical methods, and so a simple percentage agreement approach was reported.

## **External validity:**

Because the practice in this case study processed a large volume of MSK US scans it was possible to obtain a large sample of MSK cases. As a case study, the application of findings from this study are limited, however, there are a small number of sonographers that focus on MSK US in the Auckland region (personal communication, Scott Allen, 15 March 2018). Based on a request for ACC data about MSK sonography claims in Auckland, this practice does accounts for approximately 8% in the 2016 calendar year (Piuila-Afitu, 2018c). Analysing referral patterns across a number of sonography practices was beyond the scope and resources available for this project. In the absence of any published information about the nature of referral from MSK practitioners for MSK US, the aim of this research was exploratory, and sought to broadly describe what was currently being included in referrals for MSK US and sonography reports. This information can provide a platform from which future studies investigating a random sample of New Zealand diagnostic MSK US practices can be conducted.

## **Further research:**

The research is so limited with regards to referral protocols for MSK US that there are numerous areas for research. The aim of this project was to explore what was currently occurring when MSK practitioners were referring. It would be interesting to do this on a larger scale incorporating more sonographers in Auckland specialised in MSK DUSI. Alternatively, the results from this study could be used to gather a focus group of MSK practitioners and sonographers to determine a guidelines for referrers to use when requesting MSK US.

Currently, there is limited research on personal use and accessibility of MSK US by physiotherapists, none of which appears to focus on DUSI. This could be further researched, and could encompass all MSK practitioners to better examine reasoning behind utility or lack thereof.

There is also no research that has examined how MSK practitioners are incorporating the results of the MSK US report into their clinical reasoning process. Namely, whether it influences clinical decision making in terms of patient management thereby determining the appropriateness of MSK US as a tool for MSK practitioners. This should be prioritised as a research project to determine if further guideline analysis should proceed.

There appears to be a positive relationship between total number of scans and body regions that have imaging guidelines. These were likely produced due to the higher prevalence of claims for regions such as the shoulder or knee. This study also found that ankle was a commonly examined area. It would be interesting to see if the production of a new protocol would impact the use of MSK US as a tool. For example, there are Ottawa rules for the ankle, but these only suggest plain film X-ray and do not include MSK US. ACC does not have ankle guidelines despite this region constituting >12% of ACC ultrasound claims (Piula-Afitu, 2018c).

## **Conclusion**

The purpose of this research was to explore how musculoskeletal practitioners were referring and to compare the referral request with the resulting sonography report. It was found that there were a wide range of elements included (or excluded) in referrals. For example, time since injury was a key element commonly omitted from referrals. Another common omission was the referrers' presentation of their clinical query. Some referrals listed anatomical structures but no clinical query, thus failing to indicate what question the referrer wanted the sonographer address; while others listed a low number of concise queries which were often in agreement with the sonographer's opinion. This variety may

be partly attributable to limited availability of imaging guidelines for MSK practice, including none that are specific for ultrasound. The findings of this study provide insight for areas that should be further researched to encourage the development of musculoskeletal ultrasound specific referral protocols which would likely improve the quality of service and encourage multi-tier collaboration within the NZ health system.

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[practitioners-competence-assurance-act/responsible-authorities-under-act](http://www.health.govt.nz/our-work/regulation-health-and-disability-system/health-practitioners-competence-assurance-act/responsible-authorities-under-act)

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## Appendix B. Examples of referrals requests, annotated according categories for spreadsheet data extraction.

Example 1. Plantar fascia pain. This is an example of the Sound Experience referral request. It is annotated to show how information was extracted into the categories for this project.

506,437      R031      2-5/16

**SOUND EXPERIENCE ULTRASONOGRAPHY**  
 Clinic 41, Unitec, Gate 3, 139 Carrington Road, Mt Albert, Auckland 1025. Ph: 815 6794  
 Flexa Clinic, 160 Lake Road, Northcote, Auckland 0627. Ph: 481 0670

BOOKINGS ONLINE  
 www.soundexperience.co.nz  
 or Txt: 027 906 4884

Surname	Patient descriptors- DOB, Sex	<input type="radio"/> Miss <input checked="" type="radio"/> Mrs <input type="radio"/> Ms <input type="radio"/> Mr
First Name		<input type="radio"/> Male <input checked="" type="radio"/> Female
Address		Date of Birth: 172
Daytime Contact Phone Numbers	Free Text	NHI#
<b>MSK</b> <input type="radio"/> Shoulder <input type="radio"/> Elbow <input type="radio"/> Wrist <input type="radio"/> Hand <input type="radio"/> Hip <input type="radio"/> Thigh	<b>General</b> <input type="radio"/> Upper abdo <input type="radio"/> Hernia <input type="radio"/> Renal <input type="radio"/> Thyroid/neck <input type="radio"/> Scrotum <input type="radio"/> Other	ACCH# ^
		<input type="radio"/> Knee <input type="radio"/> Calf <input type="radio"/> Ankle <input checked="" type="radio"/> Foot <input type="radio"/> Other
Referred by	Ph	<b>Clinical Information</b> (required for all services) RIGHT FOOT PLANTAR FASCIAITAN. -on 08 July 2016 scan revealed an 8mm by 6mm axial intrasubstance tear and 2) plantar fasciopathy. -please rescan for follow up. Thanks
Email	Reg. No.	<b>Clinical indications:</b> -Pain at site -Hx of injury -Other relevant imaging completed
Signature	Date 07/16	<b>Time Since Injury:</b> -Not given
		<b>Query:</b> -See if healing

Pre-determined text – Region of interest

Referrer name/company

Example 2. Knee issue. This is an example of a referral request that was not made using the Sound Experience form but rather another Radiology form. The fields differ slightly but the information was categorised similarly to the first example.

Phone 0800 774 9729 (0800 SRG XRAY) · +64 (0)9 523 7054 · Post PO Box 74425, Greenlane, Auckland 1546 · Web srgmri.co.nz

506424 SRG RO31 24/11/16  
SPECIALIST RADIOLOGY + MRI GREENLANE SPECIALIST RADIOLOGY + MRI MANUKAU

027 494 7157 021 192 3686

Mr  Mrs  Ms  Miss  Dr Surname First Name

Address

DOB 87

Email

Ph (Home) Ph (Mob)

INSURANCE: NHI # ACC # Insurer #

**3 T MRI**

- C Spine
- T Spine
- L Spine
- Brain
- IAMS
- Shoulder
- Elbow
- Wrist
- Finger / Thumb
- Pelvis
- Hip

**Ultrasound**

- Knee
- Ankle
- Foot
- Arthrogram
- IV Gadolinium
- Other

**Interventional**

- Nerve Root Injection
- Facet Joint Injection
- Other

**CT**

- Musculoskeletal
- PRP Injection
- Upper Abdomen
- Renal
- Pelvis
- Obstetrics
- Carotid
- DVT
- Infection / Aspiration

**X-Ray**

- Musculoskeletal
- Spine
- Pelvis
- Abdomen
- Head
- Sinuses
- Neck
- Chest
- Other

**Nuclear Medicine**

- Long Leg Film
- Long Spine Film
- Joint Templating
- Other
- Whole Body Scan
- Bone SPECT / CT
- Other

To book, phone +64 9 638 91

**Region of Interest / Procedure**

Right knee. 2pm Thurs

Please to Sandeep... co. 12 to make booking.

**Alerts**

- Anticoagulants
- Pacemaker
- Neuro / BioStimulator
- Other

**Urgency**

- Urgent
- Routine

**Referring Practitioner**

Name: NZMR Date: Co:

**Clinical Details**

Very tear grade 1-2 of the mcl and also other changes to the gastrocnemius of the medial also the hamstring medially

**Pre-determined text - N/A**

**Free Text**

**Region of interest - Right Knee**

**Clinical indications: -Change to tissue texture**

**Time Since Injury: -Not given**

**Queries: -Grade 1-2 MCL Tear**

IANZ ACCREDITED RADIOLOGY SERVICE MEDICAL IMAGING

Example 3. Unresolving shoulder pain. This is another example of the Sound Experience form with different information available such as 'Time Since Injury'.

**SOUND EXPERIENCE ULTRASONOGRAPHY**  
 Clinic 41, Unitec, Gate 3, 139 Carrington Road, Mt Albert, Auckland 1025. Ph: 815 6794

BOOKINGS ONLINE  
 www.soundexperience.co.nz  
 or Txt: 027 906 4884

Surname _____ First Name _____ Address _____ Daytime Contact Phone Numbers _____ I.D.D. _____	Patient descriptors- DOB, Sex <input type="radio"/> Miss <input type="radio"/> Mrs <input type="radio"/> Ms <input checked="" type="radio"/> Mr <input checked="" type="checkbox"/> Male <input type="checkbox"/> Female Date of Birth _____ 1/1/85 NHI# _____ ACC# _____	Region of interest- Left Shoulder
MSK <input checked="" type="radio"/> Shoulder <input type="radio"/> Knee <input type="radio"/> Upper abdo <input type="radio"/> Elbow <input type="radio"/> Calc <input type="radio"/> Hernia <input type="radio"/> Wrist <input type="radio"/> Ankle <input type="radio"/> Renal <input type="radio"/> Hand <input type="radio"/> Foot <input type="radio"/> Thyroid/neck <input type="radio"/> Hip <input type="radio"/> Other <input type="radio"/> Scrotum <input type="radio"/> Thigh <input type="radio"/> Other	General Pregnancy <input type="radio"/> Early (<12 wks) <input type="radio"/> N.T (12 wks) <input type="radio"/> Anatomy <input type="radio"/> 3 <sup>rd</sup> Trimester	Clinical Information (required for all services) - unresolving @ on L Shoulder during overhead activities since 26/09/2015 - ? L subdeltoid bursitis
Referred by _____ Email _____ Signature _____	Ph _____ Reg. No. _____ Date 17/11/2016	Clinical indications: -Pain in region -Pain not responding to treatment -Pain on specific movement Time Since Injury: -8 weeks Queries: -Subdeltoid Bursitis



## Appendix C. Examples of sonographer reports, annotated according to categories of spreadsheet data extraction.

These are examples of the Sound Experience reports. Each example corresponds to the same numbered request seen in Appendix B.

Example 1. Plantar fascia pain.

**Sound Experience Ltd**  
 Clinic 41, Gate 3, 139 Carrington Rd, Mt Albert, Auckland 1025  
 Phone (09)815-6794 or 027 9064884. Fax (09)815-4388

Referrer contact details

Patient contact details	DOB:	Patient descriptors- DOB, Sex, ACC number
	Gender:	
	ACC:	
Ph: _____	Visit Number:	
Referred by: J. ....	Scan date: 25 November 2016	

Repeated information for referrer sheet  
 Region- Hind foot  
 TSI- ~26 weeks  
 CI- Other relevant imaging  
 Query- To see if healing

Thank you for referring your patient for assessment of the heel.

**Clinical Indication:** Right foot plantar fascia pain. On 08/07/2016 scan revealed an 8mm long by 6mm axial into substance tear and right plantar fasciopathy. Please rescan for follow up.

**Findings:**  
**Right Heel:**  
 The plantar fascia origin is thickened (7 mm) and is heterogeneous in appearance with. No tear or vascularity is seen.  
 The tibialis posterior, flexor hallucis longus and the flexor digitorum longus tendons, and abductor hallucis muscle and tibial nerve are normal.

**Opinion:**  
 Right plantar fasciosis with the tendon tear no longer apparent and the thickening unchanged since the scan in July 2016.

\_\_\_\_\_, Sonographer

Scanning technique:  
 Hind foot/Heel complex-  
 Plantar fascia, tibialis posterior, FHL, FDL, ABdH, Tibial nerve

No added CI by sonographer= "Sonographer referrer match"

SNOMED code-  
 Foot- Plantar fasciitis (disorder):  
 202882003

Unique code:  
 Injury Healing:  
 8

Example 2. Knee issue.

## Sound Experience Ltd

Clinic 41, Gate 3, 139 Carrington Rd, Mt Albert, Auckland 1025  
 Phone (09)815-6794 or 027 9064884. Fax (09)815-4388

Referrer contact details

	DOB:	Patient descriptors- DOB, Sex, ACC number
Patient contact details	Gender:	
	ACC:	
Ph:	Visit Number:	
Referred by:	Scan date:	24 November 2016

Repeated information for referrer sheet  
 Region- Knee  
 TSI- N/A  
 CI- Changes to tissue texture  
 Query- MCL  
 Tear

Thank you for referring your patient for assessment of the knee.

**Clinical Indication:** Right knee. Query tear grade 1-2 of the MCL and also other changes to the gastrocnemius muscle of the medial, also hamstring medially.

**Technique:** The quadriceps tendon, the patellar, biceps femoris, semitendinosus/pes anserine, and the semimembranosus tendons, and the suprapatellar recess, ilio-tibial band, medial and lateral collateral ligaments and popliteal fossa are examined.

**Findings:**  
**Right Knee:**  
 There is focal tenderness scanning over the medial knee joint line. The joint is mildly narrowed and there is a small marginal bone spur.  
 The medial collateral ligament, medial gastrocnemius, semimembranosus and semitendinosus tendons are normal.  
 The remaining knee examination is normal.  
 No knee joint effusion is seen.

**Opinion:**  
 Right knee medial joint line mild narrowing and small bone spur.  
 MRI is the best examination for examination of the menisci and the cruciate ligaments.

Scanning technique:  
 Knee complex-  
 quari-cep  
 tendon,  
 patellar, biceps  
 femoris,  
 semitendinosus  
 , pes anserine,  
 semimembran  
 osus tendons,  
 suprapateller  
 recess, iliotibial  
 band, medial  
 and lateral  
 collateral  
 ligaments,  
 popliteal fossa

No added CI by sonographer=  
 "Sonographer referrer match"

SNOMED code-  
 Foot- Plantar  
 fasciitis  
 (disorder):  
 202882003  
  
 Unique code:  
 Injury Healing:  
 8

SNOMED code:  
 MISC-  
 Osteophyte of  
 bone:  
 235231000119  
 100

Further investigation: MRI  
 Further testing structure: Menisci and cruciates

\_\_\_\_\_, Sonographer  
 Verified by \_\_\_\_\_ Radiologist

Example 3. Unresolving shoulder pain.

## Sound Experience Ltd

Clinic 41, Gate 3, 139 Carrington Rd, Mt Albert, Auckland 1025  
 Phone (09)815-6794 or 027 9064884. Fax (09)815-4388

Referrer contact details

Patient contact details

DOB:	
Gender:	
ACC:	
Visit Number:	
Referred by:	Scan date: 23 November 2016

Repeated information for referrer sheet  
 Region- Shoulder  
 TSI- 8 weeks  
 CI- Pain unresolving,  
 Pain on specific movement  
 Query- Subdeltoid bursitis

No added CI by sonographer= "Sonographer referrer match"

SNOMED code- Shoulder- Subdeltoid bursitis: 78715003  
 Impingement sign (finding): 31117002

Thank you for referring your patient for assessment of the shoulder.

**Clinical Indication:** Unresolving pain on left shoulder during overhead activities since 26/09/2015. Query left subdeltoid bursitis.

**Findings:**

**Left Shoulder:**

On abduction there is subdeltoid bursal bunching with pain and early activation of trapezius muscle at 40 degrees.

The supraspinatus tendon, the infraspinatus, teres minor, subscapularis, and the long head biceps tendons are intact and are normal in appearance.

The AC joint is normal.

Scanning technique:  
 Shoulder complex- Subdeltoid bursa, trapezius activation, supraspinatus, infraspinatus, teres minor, subscapularis, long head of biceps, AC

**Opinion:**

Subdeltoid bursitis with impingement and shoulder dyskinesia. An ultrasound guided steroid injection may be performed to relieve the patient's symptoms if clinically indicated.

Sonographer

Consider steroid

Verified by

## Appendix D. Description of scanning protocols

This is a list of the structures that were routinely included in each regional scan. For this project, this category of information was termed a ‘Scanning Protocol’.

Description of scanning protocol	Count	%
<b>Shoulder complex</b>		
Long head biceps, Subscapularis, Supraspinatus, Infraspinatus, Teres Minor, Pectoralis Major Tendon, Coracoacromial Ligament, Posterior Glenohumeral Joint/Labrum Assessment, Subdeltoid/Subacromial Bursae, Acromioclavicular Joint, Trapezius activation	284	32%
<b>Knee complex</b>		
Quaricep Tendon, Patellar, Biceps Femoris, Semitendinosus, Pes Anserine, Semimembranosus Tendons, Suprapateller Recess, Iliotibial Band, Medial And Lateral Collateral Ligaments, Popliteal Fossa	166	19%
<b>Ankle Complex</b>		
Peroneus Longus & Brevis, Calcaneofibular ligament, Anterior Inferior Tibiofibular Ligament (Syndesmosis), Anterior Talofibular Ligament, Extensor Digitorum Longus & Brevis, Extensor Hallucis Longus, Tibialis Anterior, Dorsal Talonavicular Ligament, Bifurcate Ligament , Tibialis posterior, Flexor Digitorum Longus, Flexor Hallucis Longus, Deltoid Ligament	146	16%
<b>Calf Complex</b>		
Soleus, Gastrocnemius, Plantaris, Achilles	61	7%
<b>Hip Complex</b>		
Iliopsoas, Rectus Femoris, Hamstring Origin, Gluteal Tendons, ITB, Bursa, Acetabular Labrum	52	6%
<b>Elbow Complex</b>		
Common Extensor Origin & Radial Collateral Ligament, Triceps, Common Flexor Origin & Medial Collateral Ligament, Biceps Brachii,	50	6%

Anterior and Posterior Elbow Joint, Deep Radial (Posterior Interosseous) Nerve, Median Nerve

**Forefoot Complex**

Metatarsal Phalangeal Joints, Interdigital Spaces, Flexor/Extensor Tendons of toes 34 4%

**Hind foot/Heel complex**

Plantar Fascia, Tibialis Posterior, Flexor Hallucis Longus, Flexor Digitorum Longus, Abductor Hallucis, Tibial nerve 32 4%

**Wrist complex 2**

1st Compartment – Abductor Pollicis Longus & Extensor Pollicis Brevis, 2nd Compartment – Extensor Carpi Radialis Longus & Brevis, 3rd Compartment – Extensor Pollicis Longus, 4th Compartment – Extensor Digitorum & Extensor Indicis, 5th Compartment – Extensor Digitorum Minimi, 6th Compartment – Extensor Carpi Ulnaris, Scapholunate Ligament, Dorsal Intercarpal Ligament, Flexor Carpi Radialis, Flexor Pollicis Longus, Flexor Digitorum Superficialis & Profundus, Flexor Capri Ulnaris, Distal Radioulnar Joint, Proximal & Distal Wrist, Triangular Fibrocartilage Complex – incompletely seen, 1st Carpometacarpal Phalangeal Joint 29 3%

**Hamstring/posterior thigh complex**

Semitendinosus, Semimembranosus, Biceps Femoris Muscles and Insertions, Sacrotuberous Ligaments, Sciatic Nerve 26 3%

**Wrist complex**

Carpal Tunnel, Flexor Tendons, Median & Radial Nerves, Radial Artery 5 1%

---

**Total 885 100%**

---

**Missing 115 12%**

---

**Appendix E. Table of regions within Calf/Ankle/Foot (CAF) group**

CAF Text regions	Count	%
Lower Limb - ankle	164	43%
Lower Limb - foot	92	24%
Lower Limb- calf	71	19%
Lower Limb- hind foot	21	6%
Lower Limb- fore foot	12	3%
Lower Limb- shin	6	2%
Lower Limb- knee	4	1%
Lower Limb- Planter foot	4	1%
Lower Limb- mid foot	2	1%
Lower Limb- anterior thigh	1	0%
Lower Limb- posterior thigh	1	0%
Upper Limb- shoulder	1	0%
<b>Total</b>	<b>379</b>	<b>100%</b>

## **Appendix F. Correspondence with ACC Operations Services, Analytics & Reporting 1**

This was the first request for information to ACC, for the total claims and top 20 codes used for MSK US in 2016 and 2017. Only includes '*Service item- U3I- Musculo-skeletal*'.

OPERATIONS SERVICES, ANALYTICS & REPORTING

Official Information Act (OIA) response

Musculoskeletal ultrasound claims in Auckland



To: Olivia Furlong  
 Author: Emi Piulla-Afitu, Response Analyst

Redmine Ref: 45434  
 Date: 05/02/2018

**Question**

Under the Official Information Act, Analytics and Reporting have been asked to provide the number of claims to receive a musculoskeletal ultrasound in the 2016 calendar year, where the vendor region is in Auckland.

**Response**

**Table one: Count of claims to receive a musculoskeletal ultrasound in the period 1 January 2016 to 31 December 2017, where the Vendor is located in the Auckland region.**

Service Calendar Year	Claims Paid Count
2016	21,171
2017	22,099

**Table two: The top 20 injury read codes associated with the claims identified in table one.**

Read Code	Read Code Description	Claims Paid Count		
		2016	2017	Total
S550.	Ankle sprain	2,880	3,110	5,990
S54..	Sprain of knee and leg	1,859	1,987	3,846
S51..	Sprain of elbow and forearm	1,177	1,278	2,455
S53..	Sprain of hip and thigh	979	1,061	2,040
S54x1	Sprain gastrocnemius	952	931	1,883
S5504	Sprain, tendocalcaneus (Achilles tendon)	941	885	1,826
S551.	Foot sprain	827	839	1,666
S520.	Sprain wrist ligament	662	732	1,394
S572.	Lumbar sprain	524	531	1,055
S541.	Sprain of medial collateral ligament of knee	494	520	1,014
S522.	Sprain thumb	388	400	788
S535.	Sprain, hamstring tendon	378	392	770
SE41.	Contusion, knee and lower leg	394	342	736
S50..	Sprain of shoulder and upper arm	295	356	651
S524.	Sprain tendon wrist or hand	297	316	613
S52..	Sprain of wrist and hand	244	289	533
S523.	Sprain finger	221	244	465
S5V0.	Rupture achilles tendon	225	234	459
S540.	Sprain or partial tear, knee, lateral collateral ligament	220	212	432
S54y.	Knee sprain NOS	197	235	432



**Caveats / notes on data**

Accredited employer claims are excluded from the information

Musculoskeletal ultrasound has been identified by the Service Item '*U31 - Us Musculo-Skeletal*'

Musculoskeletal ultrasound was completed in the period 1 January 2016 to 31 December 2017.

The Vendor who completed the musculoskeletal ultrasound is located in the Auckland region.

For table two only the primary diagnosis for the claim has been identified, as a claim may have multiple diagnoses.

The primary diagnosis may not be the diagnosis that the ultrasound was required for, however ACC is unable to link a service such as ultrasound to a specific diagnosis.

A client may have more than one active claim in the specified period of time, therefore counts reflect the number of unique claims and not the number of clients.

A calendar year is 1 January to 31 December.

Data was extracted on 25 January 2018 and may differ if re-run at a later date.

## **Appendix G. Correspondence with ACC Operations and Analytics 2**

This was the second request for information from ACC for the total number of claims for most common regions referred for in this project (shoulder, Knee, CAF). Only uses '*Service item- U31-Musculo-skeletal*'. This explains the low numbers of claims for Shoulder as it is a separate code '*U30- US Shoulder*'(see Appendix H.).

OPERATIONS SERVICES, ANALYTICS & REPORTING

Official Information Act (OIA) response

Musculoskeletal ultrasound claims in Auckland



To: Olivia Furlong

Author: Emi Puila-Afitu, Response Analyst

Re dm line Ref: 45434

Date: 23/02/2018

**Question**

Under the Official Information Act, Analytics and Reporting have been asked to provide the number of claims to receive a musculoskeletal ultrasound in the 2016 calendar year, where the vendor region is in Auckland.

**Response**

The below table gives a count of the number of claims to receive a musculoskeletal ultrasound where:

- the primary injury site is as given;
- the Vendor is located in the Auckland region; and
- the ultrasound was completed in the calendar year given.

Please note that the primary injury site for the claim has been identified, but a claim may have multiple injury sites.

The primary injury site maybe not be the injury site that the ultrasound was required for, however ACC is unable to link a service such as ultrasound to a specific site

Table one: Count of claims to receive a musculoskeletal ultrasound where the claims primary injury site is the below, in the period 1 January 2016 to 31 December 2017, and where the Vendor is located in the Auckland region.

Primary Injury Site	Claims Paid Count		
	2016	2017	Total
Ankle	4,747	5,078	9,749
Foot	1,316	1,379	2,680
Knee	3,874	4,014	7,863
Lower Leg	1,288	1,283	2,558
Shoulder (incl Clavicle/blade)	614	740	1,351

**Caveats / notes on data**

- A calendar year is 1 January to 31 December.
- Accredited employer claims are excluded from the information.
- Musculoskeletal ultrasound has been identified by the Service Item 'U31 - Us Musculo-Skeletal'.
- Musculoskeletal ultrasound was completed in the period 1 January 2016 to 31 December 2017.
- The Vendor who completed the musculoskeletal ultrasound is located in the Auckland region.
- A client may have more than one active claim in the specified period of time; therefore, counts reflect the number of unique claims and not the number of clients.
- Data was extracted 21 February 2018 and may differ if re-run at a later date.

## Appendix H. Correspondence with ACC Operations and Analytics 3

This was the third request sent to ACC, which asked to repeat the first two requests (Appendices F and G) but including information from all codes. This was to determine the total number of ACC claims for MSK US in 2016 and 2017. As well as the total number of claims associated with this projects' most common regions (shoulder, knee, CAF). This included all relevant codes; *U23, U28, U30, U31, U39*.

**OPERATIONS SERVICES, ANALYTICS & REPORTING**

Official Information Act (OIA) response

Ultrasound claims in Auckland



To: Olivia Furlong  
Author: Auren Xu, BusinessAnalyst

Redmine Ref: 45778  
Date: 05/03/2018

### Question

Under the Official Information Act, Analytics and Reporting have been asked to provide the number of claims to receive a service under codes U23, U28, U30, U31 and U39 in calendar year 2016 and 2017, where the vendor region is Auckland.

### Response

The below tables give a count of the number of claims to receive a service under given codes where:

- the vendor is located in the Auckland region; and
- the service was completed in the calendar year given.

Please note that the primary injury site for the claim has been identified, but a claim may have multiple injury sites.

The primary injury site may not be the injury site that the ultrasound was required for. However, ACC is unable to link a service such as ultrasound to a specific site.

**Table 1: Count of claims to receive the below services where the claims include all injury sites, in the period 1 January 2016 to 31 December 2017, and where the vendor is located in the Auckland region.**

Service Calendar Year	Claims Paid Count				
	U23 - Us Veins	U28 - Us Additional Region	U30 - Us Shoulder	U31 - Us Musculo-Skeletal	U39 - Us Skeletal Miscellaneous
2016	540	6,498	17,356	21,171	9
2017	401	6,636	17,639	22,217	12

**Table 2: Count of claims to receive the below services where the claims injury site is ankle, foot, knee, lower leg and shoulder (incl. clavicle/blade), in the period 1 January 2016 to 31 December 2017, and where the vendor is located in the Auckland region.**

Service Calendar Year	Service Item	Claims Paid Count				
		Ankle	Foot	Knee	Lower Leg	Shoulder (incl Clavicle/blade)
2016	U23 - Us Veins	103	16	125	171	6
	U28 - Us Additional Region	771	169	508	153	2,956
	U30 - Us Shoulder	71	24	143	42	14,409
	U31 - Us Musculo-Skeletal	4,747	1,316	3,874	1,288	614
2017	U23 - Us Veins	75	8	80	126	7
	U28 - Us Additional Region	810	233	584	190	2,868
	U30 - Us Shoulder	68	13	147	31	14,607
	U31 - Us Musculo-Skeletal	5,082	1,379	4,014	1,283	740
	U39 - Us Skeletal Miscellaneous	< 4	0	< 4	0	0

**Caveats / notes on data**

- A calendar year is 1 January to 31 December.
- Accredited employer claims are excluded from the information.
- Service was completed in the period 1 January 2016 to 31 December 2017.
- The Vendor who completed the musculoskeletal ultrasound is located in the Auckland region.
- A client may have more than one active claim in the specified period of time; therefore, counts reflect the number of unique claims and not the number of clients.
- Data was extracted 5 March 2018 and may differ if re-run at a later date.
- Numbers under 4 are suppressed as "< 4" to ensure client privacy.

