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Diagnosing syndesmotic instability in ankle fractures

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Abstract

The precise diagnosis of distal tibiofibular syndesmotic ligament injury is challenging and a distinction should be made between syndesmotic ligament disruption and real syndesmotic instability. This article summarizes the available evidence in the light of the author's opinion. Pre-operative radiographic assessment, standard radiographs, computed tomography scanning and magnetic resonance imaging are of limited value in detecting syndesmotic instability in acute ankle fractures but can be helpful in planning. Intra-operative stress testing, in the sagittal, coronal or exorotation direction, is more reliable in the diagnosis of syndesmotic instability of rotational ankle fractures. The Hook or Cotton test is more reliable than the exorotation stress test. The lateral view is more reliable than the AP mortise view because of the larger displacement in this direction. When the Hook test is used the force should be applied in the sagittal direction. A force of 100 N applied to the fibula seems to be appropriate. In the case of an unstable joint requiring syndesmotic stabilisation, the tibiofibular clear space would exceed 5 mm on the lateral stress test. When the surgeon is able to perform an ankle arthroscopy this technique is useful to detect syndes-

motoc injury and can guide anatomic reduction of the syndesmosis. Many guidelines formulated in this article are based on biomechanical and cadaveric studies and clinical correlation has to be established.

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Key words: Ankle fracture; Syndesmosis; Ligament; Instability; Operative treatment; Stabilisation

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INTRODUCTION

A syndesmosis is a fibrous articulation in which the opposing joint surfaces are united by ligaments^[1]. The distal tibiofibular syndesmosis consists of a complex of ligaments that provides stability to this joint. The anterior and posterior tibiofibular ligaments together with the interosseous ligament form the syndesmosis. The inferior transverse tibiofibular ligament is sometimes considered a fourth ligament but is rather a continuation of the posterior tibiofibular ligament^[2].

Syndesmotoc injuries are most commonly associated

with Weber C/pronation external rotation or pronation abduction^[3] and less frequently with Weber B/supination external rotation (SER)^[4] ankle fractures. Syndesmotic injury can also occur in isolation mostly due to an exorotation trauma or in association with damage to the lateral ankle ligaments after traumatic supination^[5,6]. There could be subsequent mortise instability and this should be treated with syndesmotic stabilisation to prevent long-term complications of syndesmotic diastasis. Ramsey *et al*^[7] reported that, when the talus moves 1mm laterally, the contact area in the tibiotalar articulation is decreased by 42%. A complete disruption of syndesmosis with a disruption of the deltoid ligament causes a 40% decrease in the tibiotalar contact area and a 36% increase in the tibiotalar contact pressures^[8]. Immediate reconstruction of the unstable syndesmosis is indicated, because a delay could expedite the development of degenerative arthritis.

To date, the need for distal tibiofibular syndesmotic fixation is not fully clear despite the abundance of literature concerning the treatment of ankle fractures and isolated syndesmotic injuries^[9]. The syndesmotic screw or other stabilising techniques are all effective in stabilising the distal tibiofibular syndesmosis to allow ligamentous healing or to allow a fibrous union^[10]. Despite the numerous biomechanical and clinical studies concerning ankle fractures, there are no consistent recommendations regarding the technical aspects of placement in syndesmotic screw fixation^[11].

The placement of a syndesmotic screw may require an additional operation for removal of the screw and both operations are not without complications. Late repairs are satisfactory but result in less favorable outcomes than properly treated acute injuries^[12]. It is not easy to regain complete stability by means of these secondary procedures^[12]. Because of these conflicting factors it is important to clearly identify the patients who will require (temporary) distal tibiofibular syndesmotic stabilisation. The precise diagnosis of syndesmosis disruption is challenging and a distinction should be made between syndesmotic ligament disruption and real syndesmotic instability. History and physical examination are not completely reliable indicators because of symptoms due to the ankle fracture itself.

PRE-OPERATIVE ASSESSMENT

Radiographic measurements such as tibiofibular overlap, tibiofibular clear space, medial and superior clear space are of little value in detecting syndesmotic injury^[13,14], probably because all these parameters depend on the rotation of the ankle^[13,15]. Even additional quantitative measurement of all syndesmotic parameters with repeated radiographs of the ankle can only be used only as

a guide in the diagnosis and management of syndesmotic injuries and not solely relied upon for treatment decisions^[13,14].

Although Maisonneuve ankle fractures always require syndesmotic stabilisation^[16], there is no correlation between the level of the fibula fracture and the need for syndesmotic stabilisation^[17-19]. This is possibly because the level of the fibular fracture does not correlate reliably with the integrity or extent of the interosseous membrane tears and the status of the strongest posterior syndesmotic ligament in operative ankle fractures^[14].

Based on a cadaver study, Boden *et al*^[20] proposed that syndesmotic fixation is unnecessary if rigid medial malleolar fixation can be achieved or, in the case of deltoid disruption, the fibular fracture is 3 to 4.5 cm proximal to the ankle joint. Recently we observed that the Boden criteria may be helpful in planning, but may have some limitations as a predictor of syndesmotic instability in distal pronation-external rotation ankle fractures^[19].

Even the Lauge-Hansen classification is not able to predict syndesmotic instability. This system can be used only as a guide in the diagnosis and management of ankle fractures and not solely relied upon for decisions on treatments such as syndesmotic stabilisation^[21].

Computed tomography scanning^[22], ultrasound^[23] and magnetic resonance imaging (MRI)^[24,25] could be valuable in detecting syndesmotic disruption in patients with chronic or isolated syndesmotic injuries but their usefulness in predicting instability in acute ankle fractures is not proven. Vogl *et al*^[26] and Oae *et al*^[27] concluded that magnetic resonance imaging of the syndesmotic complex is a highly sensitive and specific tool for the evaluation of syndesmotic injury^[26] and even syndesmotic disruption^[27].

MRI does not provide a dynamic assessment of the distal tibiofibular syndesmosis, so although a rupture of one or more of the ligaments can be identified, instability cannot be diagnosed but only suspected with a MRI scan. Another disadvantage is that the MRI is expensive and often not readily and rapidly available^[28].

Pre-operative assessment is less valuable in detecting syndesmotic instability in acute ankle fractures but can be helpful in planning.

INTRA-OPERATIVE ASSESSMENT

Jenkinson *et al*^[29] concluded that fluoroscopic stress examination of rotational ankle fractures significantly increases the rate of detection of syndesmotic instability when compared to preoperative evaluation based on standard radiography and biomechanical criteria.

The external rotation test used as a manual stress or a gravity stress test is widely recognized as a clinical tool for the diagnosis of deltoid ligament incompetence in SER ankle fractures^[30]. The role of stress radiography in

Table 1 Arthroscopic assessment of distal tibiofibular syndesmotic stability

Study, yr	Patients	Test
Takao <i>et al</i> ^[39] , 2001	38 Weber B fractures, 26 males, 40 yr	Arthroscopic anatomical examination of anterior tibiofibular ligament, the posterior tibiofibular ligament, and the transverse tibiofibular ligament. The interosseous ligament and membrane were not assessed Syndesmotic disruptions were diagnosed in 16 of 38 patients (42%) by AP radiography, in 21 of 38 patients (55%) by mortise radiography, and in 33 of 38 patients (87%) by ankle arthroscopy > 2 mm movement in between the tibia and fibula during arthroscopy
Sri-Ram <i>et al</i> ^[37] , 2005	1 Maisonneuve ankle fracture, image intensifier showed no syndesmotic diastasis	≥ 2 mm displacement of lateral malleolus in coronal or sagittal plane. Displacement of anterior border of the lateral malleolus at least 2 mm more than displacement of the posterior border of the lateral malleolus 16 cases had positive intraoperative stress radiographs; 35 cases had positive arthroscopic findings of syndesmosis diastasis, including various combinations of coronal, sagittal, and rotational planes of instability Distal tibiofibular joint instability was detected by a squeeze test under fluoroscopy or by residual, arthroscopically observed diastasis of the joint Persistent instability of the distal tibiofibular joint, which was detected under fluoroscopy and arthroscopy in 8 patients
Lui <i>et al</i> ^[38] , 2005	53 Weber B and C fractures, 35 yr, without radiographic evidence of frank syndesmosis diastasis	
Ono <i>et al</i> ^[40] , 2004	105 ankle fractures, 59 males, 46 yr	
Takao <i>et al</i> ^[36] , 2003	52 acute ankle injuries, 31 males, 35 yr	Arthroscopic anatomical assessment of AITFL and the PITFL, transverse ligament, interosseous ligament and membrane were not assessed The accuracy of AP radiography, mortise radiography and MRI was compared with arthroscopy for the diagnosis of a tear of the tibiofibular syndesmosis
Hintermann <i>et al</i> ^[41] , 2002	148 chronic ankle instabilities, 38 males, 34 yr	Arthroscopic anatomical assessment of AITFL, PITFL, and the transverse ligament

the diagnosis of distal tibiofibular syndesmotic instability is less clear^[28], although recent data have suggested that many surgeons (69%) use the intra-operative lateral stress test to assess syndesmotic stability^[31].

The absence of distal tibiofibular diastasis on static radiographs is not sufficient to exclude syndesmotic instability in patients with ankle injuries.

Intra-operative stress testing, in sagittal, coronal or exorotation direction, is essential in the diagnosis and treatment of rotational ankle fractures.

Which test?

On the basis of a biomechanical cadaveric study, Stoffel *et al*^[28] concluded that use of the lateral (bone hook) stress test or Cotton test^[32] and examination of the tibiofibular clear space on stress radiographs intra-operatively is more reliable, because of the greater displacement when performing this test, than the exorotation stress test.

The “Hook” or “Cotton” test is more reliable than the exorotation stress test.

Which direction?

Several authors^[28,33,34] have concluded that assessment of sagittal plane movement appears to be a more sensitive test of inferior tibiofibular instability than assessment of movement in coronal plane^[33]. Coronal plane instability as observed on an AP mortise view only occurs where the deltoid ligament or the whole interosseous membrane is also divided^[33]. Candal-Couto *et al*^[33] used the Hook test

in both directions and Xenos *et al*^[34] used the exorotation test.

The lateral view is more reliable than the AP mortise view because of the greater displacement in this direction. When the Hook test is used the force should be applied in the sagittal direction.

How much force?

Most studies do not report the level or type of force used in tests to detect syndesmotic instability^[28]. Boden *et al*^[20] used a combined pronation-external rotation force of 440 N, whereas Stoffel *et al*^[28] used an external rotation load of 150 N resulting in an external moment of 7.5 Nm. The tibiofibular clear space is relatively independent of external rotation force and there may be no benefit in using an external rotation moment of more than 7.5 Nm^[28]. In this study a lateral force of 100 N was applied to the ankle mortise and forces of > 100 N did not show any substantial increase in displacement^[28].

Based on these data, application of a force of 100 N seems appropriate.

How much displacement?

Currently available literature does not provide clear guidelines for the amount of displacement or degree of diastasis required for performing syndesmotic stabilisation.

Jenkinson *et al*^[29] used a 1-mm increase in tibiofibular clear space on an external rotation stress radiograph as an indication for syndesmotic stabilisation. However,

this may probably lead to overtreatment of many ankle fractures^[28]. Leeds *et al*^[35] suggested 2 mm as an unacceptable increase in the tibiofibular clear space. In addition, Stoffel *et al*^[28] showed that syndesmotic injuries correlate with relatively small increases in the measurements on stress radiographs. The ability of the surgeon to manually detect these small increases in intra-operative tibiofibular clear space has been questioned^[29].

Stoffel *et al*^[28] formulated guidelines for clinical practice. The superior clear space in a normal ankle joint is approximately 3 to 4 mm, which is also the maximum tibiofibular clear space value indicating a stable ankle joint. In the case of an unstable joint requiring syndesmotic stabilisation, the tibiofibular clear space would exceed 5 mm on the lateral stress test^[28].

Clinical studies are now required to determine the acceptable degree of displacement of the distal tibiofibular syndesmosis after ankle fracture fixation. In the case of an unstable distal tibiofibular syndesmosis requiring stabilisation, the tibiofibular clear space would exceed 5 mm on the lateral stress test.

ARTHROSCOPY

Recent publications^[36-41] (Table 1) state that ankle arthroscopy is a more sensitive method than intraoperative stress radiography^[36-38]. Moreover, ankle arthroscopy can aid analysis of different patterns of syndesmosis diastasis and also guide anatomic reduction of the syndesmosis^[37]. However, there are some limitations of these studies as it is not known how much diastasis the syndesmosis allows and whether the physiologic laxity is similar in the anterior and posterior part of the syndesmosis. It is known that the distance between the tibia and fibula is variable over the joint line. The central part contains the tibiofibular syndesmotic recess whose dimensions are not known. I agree with Takao *et al*^[36,39] that arthroscopy is very valuable for the accurate diagnosis of a tear of the tibiofibular syndesmosis. However, the observation of a ruptured anterior syndesmotic ligament during arthroscopy does not mean that there is syndesmotic instability because the interosseous ligament and the interosseous membrane cannot reliably be assessed during ankle arthroscopy. In most SER IV ankle fractures the anterior and posterior syndesmotic ligaments are ruptured but syndesmotic instability is rare^[42]. Ankle arthroscopy is useful for identifying ruptures of the syndesmotic ligaments intraoperative, although the test is more invasive and not all surgeons have the expertise to perform an ankle arthroscopy.

The advantage of this technique is that it provides assessment of different planes of instability and assists anatomic reduction of the syndesmosis. Syndesmotic stabilisation without direct visualization has a high percentage of malreduction^[43]. Even surgeons with arthroscopic

experience state that intraoperative radiography still plays an important role in assessing fracture reduction as well as proper restoration of fibular length and longitudinal orientation of the syndesmosis^[38]. Future research is required into the amount of displacement of the fibula in relation to the tibia, necessary to detect syndesmotic instability. When the surgeon is able to perform an ankle arthroscopy this technique is useful to detect syndesmotic injury and guide anatomic reduction of the syndesmosis.

DISCUSSION

General radiographic criteria for syndesmotic fixation are of low value compared with the intraoperative impression of the syndesmotic stability in all operated ankles. Preoperative planning is essential but not sufficient to determine the necessity for syndesmotic fixation. The pre-operative assessments can be used only as a guide in the diagnosis and management of syndesmotic instability associated with ankle fractures and cannot be solely relied on for treatment of these injuries. Other factors influencing the choice of fixation include the presence of posterior malleolus fractures, deltoid ligament injuries, and subluxation of the fibula^[2,44]. The decision to stabilize the distal tibiofibular syndesmosis should be made based on intra-operative (stress testing of arthroscopic) findings.

There is a lack of published information, particularly in relation to the performance of intra-operative stress testing of syndesmotic stability. So far, there are no clear answers to the questions: which test?, which direction?, how much force?, how much displacement? Many of the guidelines outlined in this article are based on biomechanical and cadaveric studies and clinical correlation has to be established.

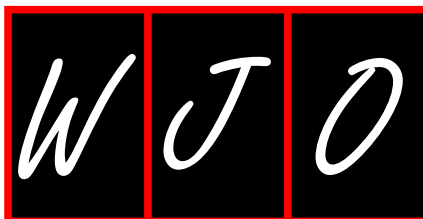
Whenever the surgeon is in doubt about syndesmotic instability, I believe stabilisation of the distal tibiofibular joint should be performed because of the problems caused by chronic syndesmotic instability^[9,12].

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Ultrasound-assisted musculoskeletal procedures: A practical overview of current literature

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ultrasound-based musculoskeletal procedures. In-depth discussion of each ultrasound procedure including pertinent technical details, indications and contraindications is provided. Despite the limited amount of prospective, randomized data in this area, a substantial body of observational and retrospective evidence suggests potential benefits from the use of musculoskeletal bedside sonography.

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Key words: Musculoskeletal ultrasound-guided procedures; Arthrocentesis; Tendon injection; Articular injection; Fluid collection; Abscess drainage; Foreign body removal

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Abstract

Traditionally performed by a small group of highly trained specialists, bedside sonographic procedures involving the musculoskeletal system are often delayed despite the critical need for timely diagnosis and treatment. Due to this limitation, a need evolved for more portability and accessibility to allow performance of emergent musculoskeletal procedures by adequately trained non-radiology personnel. The emergence of ultrasound-assisted bedside techniques and increased availability of portable sonography provided such an opportunity in select clinical scenarios. This review summarizes the current literature describing common

INTRODUCTION

Bedside procedures involving the musculoskeletal system have traditionally been performed by highly trained specialists. Due to reliance on a select group of practitioners, many procedures may be delayed despite their often urgent nature. As a result, a need arose for more portable and accessible means to allow performance of emergent musculoskeletal procedures by adequately trained emergency surgical and non-surgical personnel. The emergence of ultrasound-assisted bedside techniques and increased availability of portable sonography provided such an opportunity in select clinical scenarios.

The purpose of this review is to summarize the current literature for the most common ultrasound-based musculoskeletal procedures. A thorough discussion of each ultrasound procedure including pertinent technical details and procedural indications/contraindications is included. Although there is a limited number of prospective, randomized studies in this clinical area, there is a significant amount of observational and retrospective evidence that demonstrates potential benefits that stem from ultrasound use in musculoskeletal bedside sonographic applications.

This review will be presented as a series of focused, clinical procedure-oriented sections, each of which is further sub-divided into procedural rationale (including indications and contraindications) and technical overview. Due to the limited scope of this review, the reader is referred to primary literature sources throughout the manuscript for further information pertaining to each topic/procedure.

ARTHROCENTESIS

Rationale

Arthrocentesis involves the aspiration of a synovial joint space, for both therapeutic and diagnostic indications^[1]. It is a commonly performed procedure, with an estimated 50%-62% of general medicine physicians utilizing information from arthrocentesis to guide patient management^[2]. Given the relative simplicity of the procedure and the overall prevalence of joint problems, a general level of comfort with arthrocentesis should be attainable among a variety of medical and surgical specialists. Major clinical indications include: (1) undiagnosed effusion; (2) undiagnosed arthritis; (3) septic arthritis; and (4) symptomatic relief of effusion. Contraindications to arthrocentesis include: (1) active infection overlying the puncture site; (2) tumor/mass overlying the site; and (3) rash overlying the sampling site (relative contraindication).

Adequate anatomic characterization of the intended joint space must be performed prior to arthrocentesis. Physical examination and knowledge of anatomy are crucial to a safe and effective performance of arthrocentesis. With the advent of modern imaging modalities, the practitioner now has multiple methods of anatomic characterization and pre-procedural planning (magnetic resonance imaging, computed tomography, and ultrasound). It is important to note that the physical exam, when compared to ultrasound of the knee, had only a 59% sensitivity and 65% specificity for detection of knee effusions^[3]. This may be due to the finding that the minimal volume of fluid needed for detection on knee ultrasound is approximately 7-10 mL^[4]. Having said that, when compared to other imaging modalities, joint ultrasonography is of uncertain value for purely diagnostic purposes. Thus, the most practical use would be for guidance in diagnostic and therapeutic arthrocentesis^[5].

Current evidence suggests that ultrasound-guided arthrocentesis may be less technically difficult for emer-



Figure 1 Ultrasound-guided arthrocentesis allows confirmation of the needle within the articular space and real-time visualization of fluid withdrawal. Flow can be noted within the articular space by using color or doppler flow while compressing the joint space. This technique prevents inaccurately inserting the needle within solid masses. Note the needle is best visualized when the probe is perpendicular to the needle. Long arrow indicates tibia cortical bone. Short arrow indicates needle tip. Star indicates joint space.



Figure 2 Ultrasound-guided arthrocentesis should be performed by first assessing the joint space for an effusion followed by direct observation of the needle entering the effusion. Use of ultrasound-guided arthrocentesis is highly accurate compared to blind or landmark-techniques for smaller joint spaces such as the tibiotalar joint demonstrated in the image above. Landmarks within the ultrasound image include the bone appearing as a hyperechoic region with superficial tissues including tendons and muscle appearing as heterogeneous echoic regions. Fluid within the joint space appears as hypoechoic shapes that conform to the space. Single white arrow indicates the tibia; double white arrow indicates the talus. Star indicates the tibiotalar effusion.

gency physicians, less time consuming, and produce less pain than the traditional “blind” arthrocentesis^[6]. Specifically, cadaver-derived evidence shows that ultrasound-guided arthrocentesis has a higher success rate compared to traditional blind arthrocentesis, particularly in the smaller joints (metatarsophalangeal, metacarpophalangeal, and proximal interphalangeal joints)^[7,8]. This highlights potential advantages of ultrasound-guided arthrocentesis over traditional methods, especially given the ability of sonography to provide direct visualization of pertinent anatomic structures and confirm accurate entrance of the needle into the joint space (Figures 1 and 2).

Technique overview

The ultrasound-guided arthrocentesis is performed under

standard precautions with appropriate draping of the joint and sterile procedure site preparation. Mandatory procedure site and laterality verification is performed. The ultrasound probe of choice will be determined by the joint of interest. In general, an appropriate probe choice is the linear probe (5-10 MHz) which provides good visualization of most superficial joints^[7,8]. If the joint of interest is deep and the linear probe is unable to provide adequate visualization of the space, a curvilinear probe may be necessary. The ultrasound probe is placed in a sterile cover with ultrasound gel within the probe cover or sterile ultrasound gel placed over the joint space in order to obtain adequate quality images. To help determine the intended joint space, the following recommended sonographic criteria may be helpful: (1) anechoic or hypoechoic space; (2) no evidence of flow under color doppler or power doppler; (3) compressible space under direct probe pressure; (4) hyperechoic region deep to the space of interest indicating the cartilage; and (5) hyperechoic region relative to hyaline cartilage, indicating bone^[7]. After verifying the site of interest, the ultrasound probe should be placed such that the aspirating needle will be directly visualized as it enters the intended fluid space. The needle is inserted into the space under direct observation and the fluid is aspirated with or without direct visualization.

TENDON AND ARTICULAR INJECTIONS

Rationale

Muscle and tendon injections are utilized for various musculoskeletal complaints. One common indication for tendon injections is tendinopathy. Tendinopathies affect over 500 000 people in the United States alone^[9]. Efficacy and safety of injections for management of tendinopathies vary based on the affected site^[10], with the most promising results in the treatment of first annular pulley tendinitis^[11]. Conversely, injections at other sites including the Achilles tendon are controversial as some studies have shown potential adverse effects on biomechanical properties and incidences of tendon rupture^[12,13]. Injections of articular surfaces of joints have been used as a therapy for arthritides and other inflammatory joint conditions. A brief summary of the clinical indications and contraindications are listed below in Table 1. The role of medication injections in the symptomatic and therapeutic treatment of musculoskeletal disease is beyond the scope of this review^[14,15].

Injection of tendons and articular surfaces requires a thorough knowledge of the anatomy as well as a detailed physical examination to determine the optimal injection site and placement of the injection agent. Given the great number of anatomic structures surrounding tendons and articular surfaces, as well as the lack of true physical feedback during needle placement, ensuring safe and appropriate placement may be extremely difficult. The use of advanced imaging techniques such as magnetic resonance imaging (MRI), computed tomography (CT),

Table 1 Ultrasound-guided tendon and articular injections: indications and contraindications

Indications	Contraindications
Tendinopathy Achilles tendinitis Trigger finger Carpal tunnel syndrome Lateral epicondylitis Rotator cuff tendinopathy Dequervain tenosynovitis	Rash over injection site
Bursitis Trochanteric bursitis Olecranon bursitis	Infection over injection site or obstructing injection path Tumor over injection site or obstructing injection path

Table 2 Ultrasound-guided tissue biopsy: indications and contraindications

Indications	Contraindications
Solitary bone lesion with indeterminate imaging characteristics	Infection on overlying site
New bone lesion in patient with known primary tumor	Rash on overlying site (relative)
Determine tumor recurrence	Uncorrected bleeding diathesis (relative)
Evaluate etiology of vertebral body compression fracture	Decreased platelet count (relative)
Determine infectious organism in chronic wound	Inaccessible site (relative)
Determine infectious organism in osteomyelitis	

and ultrasound has allowed more precise visualization of these structures. Due to inherent limitations of real-time MRI and CT scanning for symptomatic injections of the musculoskeletal system, this approach seems to be less useful than sonography.

The use of ultrasound as a real-time imaging modality to directly visualize the needle placement into the tendon or articular surface is practical and safe. Evidence has demonstrated that ultrasound-guided tendon injection reduces pain both during and after the injection, decreases overall patient discomfort, and improves joint or muscle mobility more than traditional blind injections^[16-19]. Furthermore, ultrasound-guided intra-articular injections enable the practitioner to localize fluid collections and perform simultaneous arthrocentesis^[17] (Table 2).

TECHNIQUE OVERVIEW

Ultrasound-guided tendon or articular injection is performed under standard sterile precautions and appropriate preparation/draping of the site. The ultrasound probe of choice will be determined by the intended tendon or articular surface. In general, a good initial probe choice is the linear probe (10-15 MHz) which provides adequate visualization of most superficial structures/spaces. High-

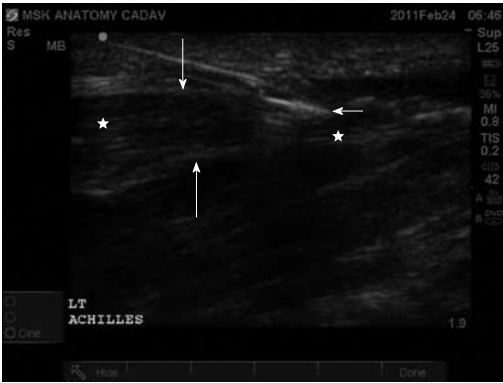


Figure 3 Percutaneous tenotomy or dry-needling can be performed under ultrasound-guidance to provide ideal visualization of the needle. Use of the short-axis plane should be to localize neighboring structures and visualize complete disruption of the tendon fibers. Use of the long-axis plane should be to confirm complete disruption of the tendon from anterior to posterior. However, the actual procedure should be performed within the short-axis plane as maintaining the needle in long-axis is difficult and unreliable to prevent neighboring structure damage. Confirmation of the structure as tendon fibers should rely on noting anisotropy which is characteristic of tendons. Short arrow indicates needle tip. Long arrows indicate Achilles tendon sheath. Stars indicate Achilles tendon fibers in long-axis plane.

frequency transducers provide the best resolution for near-field tendons, although a curvilinear probe may be needed to visualize deep joint articular surfaces. The ultrasound probe is placed within a sterile cover with ultrasound gel within the cover or sterile ultrasound gel placed directly over the intended site. After procedure site and laterality are confirmed, the site is scanned in order to inspect regional anatomy and identify any nearby neurovascular structures. In the case of tendon injections, the muscle and tendon should be scanned throughout their course to determine the safest and most optimal injection site. For articular injections, the joint space should be scanned in all dimensions to determine the safest/optimal injection site. Whenever possible, the probe is placed so that the tendon is seen in longitudinal section, as a higher success rate for tendon injections has been noted in this view. Otherwise, a transverse section can be utilized^[18]. The needle is inserted such that it is seen at all times and can be directly visualized entering the tendon or articular space. The authors recommend injection of the agent under direct visualization to prevent inadvertent application into the peri-tendinous or peri-articular structures. Representative ultrasound images can be seen in Figures 3 and 4.

TISSUE BIOPSY

Rationale

In certain clinical situations, a diagnostic biopsy may be necessary before pursuing a more definitive treatment course. The ability to rapidly diagnose and initiate treatment may help improve outcomes. The advent of ultrasound-guided biopsies of the musculoskeletal system allows an appropriately trained clinician to readily obtain

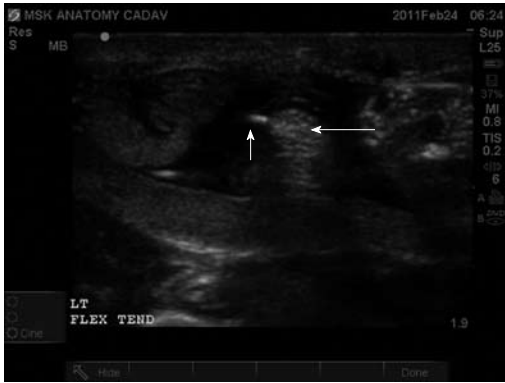


Figure 4 Ultrasound-guided injection of the left flexor tendon in transverse plane. Tendon injection under ultrasound (US)-guidance allows improved accuracy in tendon injection. Furthermore, US-guidance allows visualization of the fluid forming a complete peri-tendon fluid collection as noted by the hypoechoic space surrounding the heterogenous tendon appearance. Short arrow indicates the needle in transverse. Long arrow indicates flexor tendon in transverse section.

Table 3 Ultrasound-guided drainage and catheter insertion: indications and contraindications

Indications	Contraindications
Undiagnosed soft tissue collection	Infection on overlying site
Cyst	
Abscess	
Hematoma	
Diagnosis of Abscess	Rash on overlying site (relative)
Obtain fluid for determination of causative organism	
Treatment of known abscess	Tumor on overlying site (relative)
Aspiration	
Placement of drainage catheter (if feasible)	
Aspiration of Cyst	
Ganglion cyst	
Synovial cyst	
Determination of causative organism for osteomyelitis	

important diagnostic information in situations where a rapidly progressive disease process is being considered. Furthermore, in situations where trained interventional radiologists are either unavailable or unable to perform timely biopsies, the ability of a general clinician to perform bedside biopsies may be invaluable in conserving medical resources. In the musculoskeletal system the differential diagnosis can include a large number of pathologies (i.e. primary bone tumors, bony tumor metastases, infections, and chronic inflammatory changes). A brief listing of clinical indications and contraindications is listed below in Table 3. More comprehensive discussion of this topic is beyond the scope of this review^[20]. It should be noted that a suspected primary tumor of bone or soft tissue in the musculoskeletal system should only be biopsied by a physician trained in orthopaedic oncology. Also, biopsy performed by general clinicians or at the referring facility (rather than definitive treatment center) may in-

crease both diagnostic errors and complication rates (i.e. need for wider tumor resection at time of surgery, skin complications requiring flap coverage, increased risk of amputation)^[21].

Biopsy of the musculoskeletal system includes a broad grouping of procedures that may be divided into open and percutaneous procedures. While certain clinical scenarios preclude percutaneous biopsy and require an open procedure, percutaneous biopsy should be attempted, if possible and safe, to decrease patient discomfort and diagnostic costs^[22]. Percutaneous biopsies can be further grouped by the type of imaging guidance used to aid the clinician performing the biopsy. Traditional percutaneous biopsy consists of utilizing physical exam findings and knowledge of anatomy to place the needle within the lesion of interest, a method utilized infrequently when the depth of the lesion is beyond a few centimeters of tissue. The availability of CT-guided and fluoroscopically-guided biopsies allows the clinician to perform highly accurate needle placement into lesions that are located near critical/sensitive (i.e. neurovascular) structures or in deeper locations^[20]. Advances in ultrasound technology and clinical implementation have made ultrasound-guided musculoskeletal biopsies both feasible and accurate^[23-28]. Ultrasound-guided needle and core biopsy sensitivities in obtaining the tissue of interest range from 80%-98.4%^[23-28]. Core-needle biopsy has been demonstrated to have a higher sensitivity in obtaining diagnosis with estimated sensitivity of 81%-95% compared to 76%-80% for fine-needle aspiration^[25-27,29]. Additionally, a method of creating a portal to enable forceps to perform a comprehensive biopsy of synovium has been described^[30]. While there may be a perception that ultrasound is less facilitating when performing a diagnostic biopsy of bone lesions, evidence shows sampling accuracy for such lesions of 92%-98% for ultrasound compared to 87% for CT-guided biopsies of similar lesions^[23,25]. Conventional biopsy performed under ultrasound-guidance relies on the echogenicity of the needle to localize it during the procedure - not always an easy task. Recent improvements may further aid the clinician in visualizing the needle. For example, biopsy needles are available that have been coated with echogenic surface markers (Teflon, etched tips, and an echogenic polymer) or feature a vibration system^[29,31]. While there is limited data supporting the use of these types of needles, the use of polymer coated needles may be the most beneficial for technically difficult biopsies^[31]. While further discussion on fine-needle aspiration *vs* core-needle biopsy in musculoskeletal lesions is beyond the scope of this review, it is important to note that the suspected etiology may dictate the type of percutaneous biopsy required Table 2.

Methods

Ultrasound-guided biopsy is performed under standard sterile conditions (i.e. appropriate procedural preparation and draping) over the intended biopsy site. Site and laterality verification is essential. The choice of the ultrasound

probe, as described in previous sections, should be guided by the anatomic location of the tissue to be sampled. The linear probe (10-15 MHz) provides appropriate visualization of most superficial sites including joints, superficial muscles, and superficial bones. For sites located deeper, a curvilinear probe (5-10 MHz) may be required. The ultrasound gel is then utilized as needed throughout the course of the procedure.

The first step in performing an adequate tissue biopsy is to confirm the site of the lesion, bone or soft tissue. If the lesion is located within the bone then a larger (i.e. 14-gauge) cutting needle should be used to allow for bone fragments to be contained within the needle sample. If the lesion is located within the soft tissues then a smaller (18 or 20 gauge) needle is usually sufficient^[22-28,31,32]. Local analgesia should be used generously for all biopsy procedures and should be performed along the entire anticipated biopsy tract (including periosteum and adjacent muscles) prior to initiation of the procedure. Sedation is not universally required, but may be needed for more extensive procedures and may help facilitate more accurate sampling and improve patient comfort. When utilized, sedation requires additional monitoring (i.e. frequent vital sign and pulse oxymetry assessments) and personnel (i.e. sedation nurse and/or anesthesiologist). When possible, the performance of biopsy under local anesthetic is preferred, with sedation used if the patient is unable to tolerate the pain and/or anxiety associated with the procedure.

Prior to the incision for the biopsy, a sonographic scan of the intended biopsy site should be performed to visualize all critical anatomic structures in the area. The optimal biopsy path should be determined based on avoidance of nearby vessels/nerves, and avoidance of muscles if possible. Again, when primary musculoskeletal malignancy is suspected, it is imperative that the biopsy tract be determined by an orthopaedic oncologist, as biopsy obtained *via* an improperly planned tract may be a factor in subsequent inability to perform limb salvage surgery^[21]. Identification of vascular structures in the area of biopsy using color or power Doppler is encouraged^[31]. Detailed recording of the lesion echogenicity, margins, mass size, relation to bone (cortical invasion), and vascularity is an essential part of pre-biopsy evaluation of the intended sampling site because procedural bleeding or even the very presence of a biopsy tract can distort critical sonographic characteristics of the lesion in question^[25]. A small stab incision is then made in pre-marked skin and the biopsy needle is inserted into the lesion under direct sonographic visualization. Longitudinal orientation of the needle in relation to the ultrasound probe is preferred. Once the needle is confirmed to be within the lesion of interest, the biopsy is performed and the needle is removed with or without ultrasound visualization. A post-biopsy ultrasound scan of the region should be performed to confirm hemostasis of the sampled area. The biopsy specimen should then be handled according to established pathology guidelines regarding tissue/sample processing.

FLUID COLLECTION ASPIRATION AND DRAINAGE CATHETER INSERTION

Rationale

Tissue fluid collections are common in all areas of medicine. Therefore, practitioners in a variety of medical fields need to be aware of the relevant diagnostic and therapeutic considerations concerning tissue fluid collections. Within the realm of the musculoskeletal system, some specific subtypes of cysts and abscesses have been studied particularly closely. In general, the diagnosis of a fluid collection can be readily made using ultrasound, CT, or MRI. In many situations, the optimal therapy is either to aspirate the contents of the fluid collection or to place a drainage catheter for continuous drainage, depending on the precise character and/or size of the collection in question. A list of indications and contraindications for percutaneous aspiration or drainage catheter placement in the setting of tissue fluid collections is listed in Table 3. More comprehensive review of this topic is beyond the scope of this manuscript.

Ultrasound has been well described as a tool for diagnosis of tissue fluid collections as well as characterization of soft tissue infections^[33-35]. A brief listing of types of soft tissue infections where ultrasound can be used for diagnosis can be seen in Table 4^[33-35]. Additionally, ultrasound can be used to aid in the diagnosis of osteomyelitis, particularly in pediatric cases^[36]. There is also evidence to support the use of ultrasound in the diagnosis and characterization of soft tissue cysts in the musculoskeletal system^[37-39]. For example, the reported sensitivity and specificity for ultrasound in the diagnosis of meniscal cysts is 97% and 86%, respectively^[37]. However, evidence on the use of ultrasound as a therapeutic aid in aspiration or drainage catheter insertion is still limited. Currently, the most common method to perform fluid collection characterization is by imaging, with aspiration of fluid for analysis in clinically uncertain scenarios.

The use of ultrasound as an image-guidance method in the setting of tissue fluid collections is a relatively new concept. Among musculoskeletal applications, there may be distinct advantages of ultrasound as an image-guidance tool. Firstly, ultrasound-guided aspiration has been identified as an effective method for treating both ganglionic and synovial cysts^[40-43]. Given the evidence to support ultrasound as a diagnostic tool and the ease, cost, and lack of ionizing radiation exposure, the use of ultrasound-guidance in aspiration of these fluid collections should be considered as first-line therapy. Although a discussion of the optimal therapy for various ganglion and synovial cysts is beyond the scope of this review, there is some evidence to support the use of guided aspiration prior to or in lieu of surgical therapy^[44]. For infectious indications, the use of ultrasound for both diagnostic and therapeutic purposes is also well described^[45-52]. Ultrasound-guided aspiration or drainage catheter insertion has been successfully used to obtain fluid samples for microbial cultures as well as therapeutic drainage of

Table 4 Soft tissue infections identifiable on sonography

Cellulitis
Necrotizing fasciitis
Infective bursitis
Infective tenosynovitis
Pyomyositis
Abscess
Hydatid or Tuberculous cysts
Septic arthritis
Post-operative infection
Foreign body

collections^[46-51]. There is also evidence supporting the use of ultrasound-guided techniques in the critically ill where transporting patients between different hospital locations may be either dangerous or not at all feasible^[50]. In the case of multiple abscesses requiring drainage, the use of ultrasound guidance is further supported due to the ability to manipulate the probe rather than the patient, as well as the avoidance of excessive/additional exposure to ionizing radiation seen with CT-guidance^[48]. Another potential application of ultrasound is the performance of tissue aspiration for cultures in the diagnosis of suspected osteomyelitis. While data are still limited, the current literature suggests that ultrasound guidance can be particularly helpful when obtaining tissue samples in suspected pediatric osteomyelitis^[45].

Technique

Ultrasound-guided aspiration or drainage catheter insertion is performed under standard sterile conditions. Procedure site/laterality confirmation is essential. The ultrasound probe of choice is determined by the characteristics of the tissue in question. The linear probe (10-15 MHz) provides appropriate visualization of most soft tissue sites. For deeper lesions, a curvilinear probe (5-10 MHz) may be preferred/necessary. After placing the probe in a sterile cover and applying ultrasound gel, a brief scan through the site of interest should be performed prior to any definitive procedural intervention(s). Critical structures such as vessels and nerves should be identified. The fluid collection in question should be clearly identified and described with regards to the type (i.e. cyst), size, and overall characteristics (i.e. simple vs complex).

The ultrasound probe is then placed over the region of interest, with visualization of the needle passage in longitudinal section being preferred. The needle (typically 20- or 22-gauge) is inserted under direct sonographic visualization. Once the needle is within the fluid collection, an aspirate is obtained for analysis. If there is evidence of purulence or other signs of infection, then the placement of a drainage catheter should be considered. This involves the use of a larger needle with a guide-wire being inserted through the needle into the fluid space^[50]. After removing the needle with the guide-wire left in place, a dilator is placed over the guide-wire and the insertion site

Table 5 Percutaneous ultrasound-guided tenotomy: indications and contraindications

Indications	Contraindications
Chronic tendinosis refractory to conservative therapy Common extensor tendinosis Achilles tendinopathy Patellar tendinopathy Iliotibial tendinopathy Trigger finger	Infection on overlying site
Symptomatic tendon release Developmental dysplasia of the hip Spastic cerebral palsy Deformities of the foot	Tumor on overlying site Rash on overlying site (relative)

is expanded to accommodate an appropriately-sized catheter^[50]. The catheter is then inserted over the guide-wire and placement of the catheter within the fluid collection confirmed by direct visualization. After removing the guide-wire, the catheter is sutured in place and connected to an appropriate drainage system.

PERCUTANEOUS TENOTOMY

Rationale

Tenotomy is the complete or incomplete surgical division of a tendon for therapeutic purposes. The procedure has been described for a myriad of purposes with some of the original descriptions relating to the treatment of foot deformities^[53]. The procedure can be performed using either an open or percutaneous method. The open version of the procedure was the first described and allows direct visualization of all para-tendon structures and the pathologic region of the tendon to confirm the diagnosis^[53]. However, with the advent of percutaneous techniques, shorter procedural times and improved aesthetic outcomes became possible. Furthermore, there is evidence to suggest that percutaneous tenotomy is as safe and effective as the open procedure. It is notable that the extent of the tendinous portion divided in the muscle of interest appears directly correlated with increased postoperative mobility^[54,55]. In animal studies, ultrasound-guided percutaneous tenotomy has been shown to increase complete tendon transection and decrease damage to surrounding structures compared to palpation-guided tenotomy. A brief listing of clinical indications and contraindications for percutaneous tenotomy are listed in Table 5. A comprehensive discussion of this topic is beyond the scope of this review^[53-63].

Percutaneous tenotomy is ideally performed at the bedside or in an outpatient setting. The percutaneous approach was first described in the setting of tenotomy of the common extensor tendon for “tennis elbow” with symptomatic improvement equivalent to other surgical procedures^[64,65]. The procedure has since been implemented for a variety of tendinopathies. While the initial descriptions of percutaneous tenotomy involved blind

palpation and determination of the site using anatomic landmarks alone, recent advances in imaging modalities have significantly enhanced the anatomic accuracy of tenotomy procedures. Although CT- and MRI-guided tenotomy is possible, the literature focuses heavily on ultrasound-guidance for percutaneous procedures. Although MRI and other advanced imaging modalities offer an accurate method of diagnosing tendinopathy and/or other tendon abnormalities, the reported sensitivity of ultrasound in tendinopathies of 67%-100% is sufficient to recommend it as a screening exam based, given cost and time requirements compared to the other imaging modalities^[66,67]. There is also evidence from animal models that, compared to surface anatomy/palpation-based techniques, ultrasound-guided tenotomy may be more accurate, faster, and associated with less morbidity^[68].

Technique

Ultrasound-guided percutaneous tenotomy is performed under full sterile precautions and standard draping over the site of interest. Procedural site/laterality confirmation is essential. The ultrasound probe of choice will be determined by anatomic considerations. Most practitioners choose a high frequency (10-15 MHz) linear probe when approaching most superficial structures. If the tendon of interest is located deeper or cannot be visualized anterior to bone or cartilage, then a lower frequency (5-10 MHz) curvilinear probe may be more appropriate. Using a sterile ultrasound cover and gel, a brief scan of the site of interest should be performed prior to any invasive intervention(s). In addition to identifying any important neuro-vascular structures, the preliminary scan may help better characterize the region of interest for the tenotomy. Typical findings of tendinopathy on ultrasound include hypoechoic or anechoic regions within a tendon. Calcifications may appear as hyperechoic regions with clean shadows deep to the region, and tenderness to transducer pressure over the affected area may be present^[66,67]. Most ultrasound machines can also facilitate color or power Doppler imaging to evaluate for vascularity of the region and help guide the procedure to minimize the potential for bleeding.

Although there are different ways to perform a tenotomy, we will focus on techniques that use ultrasound-guidance. Specifically, we will discuss partial tenotomy using a needle (needling) and complete tenotomy using a scalpel^[56-61]. The anatomic region of interest is first injected with local anesthetic. There is currently no evidence to support the routine use of general anesthesia for this procedure^[56-61]. Subsequent to achieving adequate analgesia, the ultrasound probe is positioned parallel to the tendon of interest in order to help guide the procedure, preferably in the longitudinal view.

Needle-based percutaneous tenotomy is performed by using a narrow (20- or 22-gauge) needle, which is inserted under direct ultrasound guidance and penetrates the abnormal tendon region while avoiding neighboring structures. Any calcifications are disrupted during needle



Figure 5 Tendon injection can be performed in either transverse or longitudinal planes. Insertion of the needle in long-axis allows excellent visualization of the tendon sheath and tendon fibers. Prior to injection the needle tip should be well-visualized between the tendon sheath and the tendon fibers. An important method to ensure needle visualization is to angle the probe to make the angle of ultrasound wave as close to perpendicular as possible. Additionally, confirmation of a structure as a tendon involves angling the probe along the tendon to note tendon anisotropy characteristic of a tendon and not noted in nerves or vessels. Short arrow indicates needle tip in long-axis section. Long arrows indicate tendon sheath. Star indicates tendon fibers in long-axis section.

passes through the region. This is repeated under direct ultrasound visualization until the entire tendon has been disrupted by the needle.

Section tenotomy using scalpel is performed using a number 11 blade scalpel. The scalpel is inserted parallel to the tendon fibers under direct ultrasound visualization and penetrates the fibers^[57,58]. The cutting edge of the blade is initially pointed proximally on the tendon^[57,58]. The joint is then passively flexed and extended under visualization. The scalpel is then withdrawn and rotated so that the cutting edge is pointed distally on the tendon. Joint flexion and extension is then repeated^[57,58]. This produces a disruption of a single region within the tendon fibers. The procedure is then repeated by angling the scalpel so that the blade penetrates a series of tendon fibers lateral to the original incision. This is then repeated until the tendon is completely disrupted along the region of interest. The skin incision should be minimized to a single entry point, thus decreasing the chance of any additional tissue injury. A representative sonographic example of tenotomy can be seen in Figure 5.

OTHER POTENTIAL USES

Foreign body removal

Ultrasound has been utilized in diagnosis and treatment of various types of foreign bodies within the soft tissue including wood, plastic, and other radiolucent objects^[69-72]. There is evidence to support the use of ultrasound as a screening tool for foreign bodies and identification of critical neighboring structures that may present difficulty during the removal the object in question. Compared to imaging techniques such as plain radiography or computed tomography, modern ultrasound equipment is capable of rapidly producing a 3-dimensional image of the area in question and allows the physician to quickly and efficiently

plan a surgical or percutaneous removal of the foreign object. In situations where the exact nature of the foreign object is unknown, imaging methods such as MRI may be contraindicated due to the migration risk of metallic objects. Although the evidence is still limited, the use of ultrasound guidance during the removal of foreign bodies should be considered in appropriately selected cases^[69-73].

CONCLUSION

The ultimate goal of all image-guided procedures is to maximize patient safety, improve procedural accuracy, and optimize clinical outcomes. In addition to facilitating these objectives, ultrasound-guidance also offers the benefit of eliminating ionizing radiation exposure during procedures. Ultrasound-guided musculoskeletal procedures described in this review demonstrate the growing trend of using ultrasound as first-line modality in selected bedside musculoskeletal applications, among both specialist and generalist physicians. While additional information is needed to refine the utilization of ultrasound-guided bedside musculoskeletal procedures, there is sufficient evidence to support their increasing use in everyday clinical practice, as outlined in this review. The authors emphasize the need for adequate training, accreditation, and maintenance of skills among those who perform ultrasound-based procedures described herein, regardless of their specialty.

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S- Editor Sun H L- Editor Hughes D E- Editor Zheng XM

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Events Calendar 2011

January 16-20, 2011

Combined 4th International
Conference of the Saudi Orthopaedic
Association & SICOT Trainee Day,
Abha, Saudi Arabia

January 24-27, 2011

7th Middle East Orthopaedics
Conference 2011, Dubai International
Convention Centre, Dubai,
Saudi Arabia

January 28-30, 2011

National Orthopedic Conference
2011, San Francisco, California,
United States

February 15-19, 2011

American Academy of Orthopaedic
Surgeons, San Diego, CA,
United States

February 16-20, 2011

2011 Annual Meeting of the American
Academy of Orthopaedic Surgeons,
San Diego, CA, United States

February 19, 2011

Pediatric Orthopaedic Society of
North America Specialty Day, San
Diego, CA, United States

March 09-11, 2011

Annual London Imperial Spine
Course, London, United Kingdom

March 21-25, 2011

31st Caribbean Orthopaedic
Meeting, Anse Marcel, Saint Martin

March 28-April 02, 2011

The Association of Children's
Prosthetic-Orthotic Clinics 2011
Annual Meeting, Park City, UT,
United States

April 01-04, 2011

Ain Shams 2nd Orthopaedic
intensive course (Orthopaedics from
A to Z), Cairo, Egypt

April 20-22, 2011

IMUKA 2011: Masterclass in
Arthroscopy and Related Surgery,
Maastricht, Netherlands

May 11-14, 2011

2011 POSNA Annual Meeting,
Montreal, Quebec, Canada

May 12-15, 2011

84th Annual Meeting of the
Japanese Orthopaedic Association,
Yokohama, Japan

May 15-19, 2011

8th Biennial ISAKOS Congress
(International Society of
Arthroscopy, Knee Surgery and
Orthopaedic Sports Medicine), Rio
de Janeiro, Brazil

May 25-28, 2011

16th Pan Arab Orthopedic
Association Congress & 27th
SOTCOT Congress, Tunis, Tunisia

June 01-04, 2011

12th EFORT Congress in cooperation
with the Danish Orthopaedic
Association (European Federation

of National Associations of
Orthopaedics and Traumatology),
Copenhagen, Denmark

June 08-12, 2011

2011 ABJS Annual Meeting
(Association of Bone and Joint
Surgeons), Dublin, Ireland

June 15-18, 2011

11th Annual Meeting of the
International Society for Computer
Assisted Orthopaedic Surgery,
London, United Kingdom

July 07-09, 2011

66th Annual Meeting of the
Canadian Orthopaedic Association,
St. John's, Newfoundland and
Labrador, Canada

July 13-16, 2011

18th International Meeting on
Advanced Spine Techniques,
Copenhagen, Denmark

July 22-24, 2011

Sri Sathya Sai International
Orthopaedic Conference- 2011
On Pelvis And Lower Extremity
Trauma", Sri Sathya Sai Institute
of Higher Medical Sciences,
Prasanthigram, Puttaparthi, Andhra
Pradesh, India

July 25-28, 2011

2011 Update in Orthopaedics, Grand
Wailea Hotel Resort & Spa, Wailea,
Maui, Hawaii, United States

September 06-09, 2011

SICOT 2011 XXV Triennial World
Congress, Prague, Czech Republic

September 13-16, 2011

BOA/IOA Combined
Meeting(British Orthopaedic
Association & Irish Orthopaedic
Association), Dublin, Ireland

September 14-17, 2011

23rd SECEC-ESSSE Congress
(European Society for Surgery of
the Shoulder and the Elbow), Lyon,
France

September 14-17, 2011

46th SRS Annual Meeting &
Course (Scoliosis Research Society),
Louisville, Kentucky, United States

September 15-18, 2011

2011 World Congress on
Osteoarthritis, San Diego, California
92167, United States

September 21-23, 2011

HIP IMPROVEMENTS AND
PROCEEDINGS, Toulouse, France

October 25-28, 2011

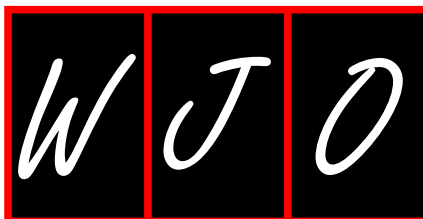
DKOU 2011-Deutscher Kongress
für Orthopädie und Unfallchirurgie,
Berlin, Germany

November 7-11, 2011

86ème Réunion Annuelle SOFCOT,
Paris, France

December 12-15, 2011

EOA 63rd Annual International
Conference, Cairo, Egypt



INSTRUCTIONS TO AUTHORS

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Acknowledgments

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- 2 **Lin GZ**, Wang XZ, Wang P, Lin J, Yang FD. Immunologic effect of Jianpi Yishen decoction in treatment of Pixu-diar-rhoea. *Shijie Huaren Xiaohua Zazhi* 1999; **7**: 285-287

In press

- 3 **Tian D**, Araki H, Stahl E, Bergelson J, Kreitman M. Signature of balancing selection in Arabidopsis. *Proc Natl Acad Sci USA* 2006; In press

Organization as author

- 4 **Diabetes Prevention Program Research Group**. Hypertension, insulin, and proinsulin in participants with impaired glucose tolerance. *Hypertension* 2002; **40**: 679-686 [PMID: 12411462 PMCID:2516377 DOI:10.1161/01.HYP.0000035706.28494.09]

Both personal authors and an organization as author

- 5 **Vallancien G**, Emberton M, Harving N, van Moorselaar RJ; Alf-One Study Group. Sexual dysfunction in 1, 274 European men suffering from lower urinary tract symptoms. *J Urol* 2003; **169**: 2257-2261 [PMID: 12771764 DOI:10.1097/01.ju.0000067940.76090.73]

No author given

- 6 21st century heart solution may have a sting in the tail. *BMJ* 2002; **325**: 184 [PMID: 12142303 DOI:10.1136/bmj.325.7357.184]

Volume with supplement

- 7 **Geraud G**, Spierings EL, Keywood C. Tolerability and safety of frovatriptan with short- and long-term use for treatment of migraine and in comparison with sumatriptan. *Headache* 2002; **42** Suppl 2: S93-99 [PMID: 12028325 DOI:10.1046/j.1526-4610.42.s2.7.x]

Issue with no volume

- 8 **Banitt DM**, Kaufer H, Hartford JM. Intraoperative frozen section analysis in revision total joint arthroplasty. *Clin Orthop Relat Res* 2002; (**401**): 230-238 [PMID: 12151900 DOI:10.1097/00003086-200208000-00026]

No volume or issue

- 9 Outreach: Bringing HIV-positive individuals into care. *HRS-A Careaction* 2002; 1-6 [PMID: 12154804]

Books

Personal author(s)

- 10 **Sherlock S**, Dooley J. Diseases of the liver and billiary system. 9th ed. Oxford: Blackwell Sci Pub, 1993: 258-296

Chapter in a book (list all authors)

- 11 **Lam SK**. Academic investigator's perspectives of medical treatment for peptic ulcer. In: Swabb EA, Azabo S. Ulcer disease: investigation and basis for therapy. New York: Marcel Dekker, 1991: 431-450

Author(s) and editor(s)

- 12 **Breedlove GK**, Schorfheide AM. Adolescent pregnancy. 2nd ed. Wiczorek RR, editor. White Plains (NY): March of Dimes Education Services, 2001: 20-34

Conference proceedings

- 13 **Harnden P**, Joffe JK, Jones WG, editors. Germ cell tumours V. Proceedings of the 5th Germ cell tumours Conference; 2001 Sep 13-15; Leeds, UK. New York: Springer, 2002: 30-56

Conference paper

- 14 **Christensen S**, Oppacher F. An analysis of Koza's computational effort statistic for genetic programming. In: Foster JA, Lutton E, Miller J, Ryan C, Tettamanzi AG, editors. Genetic programming. EuroGP 2002: Proceedings of the 5th European Conference on Genetic Programming; 2002 Apr 3-5; Kinsdale, Ireland. Berlin: Springer, 2002: 182-191

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- 15 Morse SS. Factors in the emergence of infectious diseases. Emerg Infect Dis serial online, 1995-01-03, cited 1996-06-05; 1(1): 24 screens. Available from: URL: <http://www.cdc.gov/ncidod/eid/index.htm>

Patent (list all authors)

- 16 **Pagedas AC**, inventor; Ancel Surgical R&D Inc., assignee. Flexible endoscopic grasping and cutting device and positioning tool assembly. United States patent US 20020103498. 2002 Aug 1

Statistical data

Write as mean \pm SD or mean \pm SE.

Statistical expression

Express *t* test as *t* (in italics), *F* test as *F* (in italics), chi square test as χ^2 (in Greek), related coefficient as *r* (in italics), degree of freedom as *v* (in Greek), sample number as *n* (in italics), and probability as *P* (in italics).

Units

Use SI units. For example: body mass, *m* (B) = 78 kg; blood pressure, *p* (B) = 16.2/12.3 kPa; incubation time, *t* (incubation) = 96 h, blood glucose concentration, *c* (glucose) 6.4 \pm 2.1 mmol/L; blood CEA mass concentration, *p* (CEA) = 8.6 24.5 μ g/L; CO₂ volume fraction, 50 mL/L CO₂, not 5% CO₂; likewise for 40 g/L formaldehyde, not 10% formalin; and mass fraction, 8 ng/g, etc. Arabic numerals such as 23, 243, 641 should be read 23 243 641.

The format for how to accurately write common units and quantums can be found at: http://www.wjgnet.com/2218-5836/g_info_20100724204625.htm.

Abbreviations

Standard abbreviations should be defined in the abstract and on first mention in the text. In general, terms should not be abbreviated unless they are used repeatedly and the abbreviation is helpful to the reader. Permissible abbreviations are listed in Units, Symbols

and Abbreviations: A Guide for Biological and Medical Editors and Authors (Ed. Baron DN, 1988) published by The Royal Society of Medicine, London. Certain commonly used abbreviations, such as DNA, RNA, HIV, LD50, PCR, HBV, ECG, WBC, RBC, CT, ESR, CSF, IgG, ELISA, PBS, ATP, EDTA, mAb, can be used directly without further explanation.

Italics

Quantities: *t* time or temperature, *c* concentration, *A* area, *l* length, *m* mass, *V* volume.

Genotypes: *gyrA*, *arg 1*, *c myc*, *c fos*, etc.

Restriction enzymes: *EcoRI*, *HindII*, *BamHI*, *Kho I*, *Kpn I*, etc.

Biology: *H. pylori*, *E. coli*, etc.

Examples for paper writing

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