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Concise Report

An evaluation of the effectiveness of teaching anatomy to rheumatologists through combined musculoskeletal sonoanatomy and human cadaveric dissection

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Abstract

Objective Our aim was to evaluate the effectiveness of teaching anatomy through combined musculoskeletal sonoanatomy and human cadaveric dissection for rheumatologists practising musculoskeletal US.

Methods The principal focus was on scanning and then dissecting relevant musculoskeletal structures. Outcomes measured included confidence levels and objective knowledge. A mixed-methods approach of evaluation and descriptive statistical data analysis was performed.

Results The change in confidence ratings by delegates after the teaching event as represented by the mean difference (S.D.) (S.E.M.) for identification of surface anatomy was 1.846 (1.281) (0.355), with Student's paired $t = 5.196$ and $P = 0.000223$. The mean difference (S.D.) (S.E.M) for performing IA injections was 1.538 (1.266) (0.351), with Student's paired $t = 4.382$, $P = 0.001$, and for recognizing sonoanatomical structures it was 1.769 (1.235) (0.343), with Student's paired $t = 5.165$ and $P = 0.000235$. There was a significant increase in correct identification of anatomical and sonoanatomical knowledge in the pre- and post-course assessments. Rotator cuff interval region improved from 13 to 73%, $P = 0.004$; knee tendons insertion sites from 47 to 93%, $P = 0.016$; and muscles not adjacent to joints from 27 to 93%, $P = 0.002$.

Conclusion Dissection of joints enabled a three-dimensional relational mind map of the relevant regions of the human body, producing clarity in understanding regional relational topographic anatomy and sonoanatomy. The combination of US and cadaveric dissection improved learners' satisfaction, confidence and knowledge in areas where soft tissue complaints are common, which is likely to lead to accurate early diagnosis and cost-conscious, better overall care.

Key words: clinical anatomy, sonoanatomy, cadaveric dissection, ultrasound

CLINICAL SCIENCE

Introduction

The aim of this study was to evaluate the effectiveness of teaching anatomy to rheumatologists in Singapore, using a training course that combined musculoskeletal sonoanatomy with human cadaveric dissection. Many studies have shown that the level of competency in clinical anatomy of the musculoskeletal system is deficient in rheumatology trainees, fellows and consultants [1, 2]. Despite the fact that ≤30% of rheumatology consultations are made up of regional pain syndromes, musculoskeletal anatomy has been identified as a relatively neglected component of postgraduate training in rheumatology on a global scale [3].

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Key messages

- Knowledge of musculoskeletal anatomy is essential for correct diagnosis of regional musculoskeletal soft tissue pathology.
- The level of competency in clinical anatomy is perceived to be deficient amongst rheumatologists.
- Combining cadaveric dissection and sonoanatomy is effective in increasing confidence and knowledge of anatomy amongst rheumatologists.

A deep knowledge of clinical anatomy enables the rheumatologist to perform a skilled history, interpretation and well-informed physical examination, which is essential in uncovering the underlying aetiology of the patient's problem and in providing a more cost-effective and efficient diagnostic plan. Additionally, there has been widespread use of musculoskeletal US among rheumatologists, of which a key component is the integration of an accurate knowledge of anatomy with the US images obtained. The EULAR, European Federation of Societies for Ultrasound in Medicine and Biology (EFSUMB) and ACR have produced minimal training requirements, comprehensive guidelines and standardized scanning protocols to cover anatomical structures relevant to rheumatology [4–6].

There is significant evidence to suggest that teaching skills in musculoskeletal examination and clinical anatomy are inadequate, in that too often both are taught poorly and superficially, and in most rheumatology training syllabi competency in musculoskeletal anatomy is assumed rather than verified before obtaining accreditation [7–9]. In the past few decades, the curriculum time for anatomy instruction has also been significantly reduced in undergraduate medical programmes. This might be the reason for the general decrease in knowledge of clinical anatomy by residents and doctors [10].

In view of these deficiencies, we developed a new approach to enable rheumatologists with intermediate musculoskeletal US experience (deemed equivalent to EULAR Competency Level 1 or 2) to benefit from didactic lectures on sonoanatomy, hands-on scanning and demonstrated dissection of the upper and lower limb using fresh human cadaveric specimens [11]. The goal of the dissection component was to enable learning anatomy with relevant clinical sonoanatomical correlation.

The use of a cadaveric dissection component in learning sonoanatomy for rheumatologists is not clear. Hence, the aim of this study was to investigate the impact of a clinical anatomy course combining musculoskeletal sonoanatomy with human cadaveric dissection on rheumatologists' knowledge of musculoskeletal anatomy and to explore the perceived effectiveness of the dissection component in learning sonoanatomy.

Methods

Anatomy sessions

The anatomy sessions were undertaken in a small group setting. In each group there were four or five course attendees and two faculty members. The teaching was divided into two parts, with the hands-on US sonoanatomy training before the demonstration of gross anatomy through dissection. Entire limbs, rather than whole cadavers, were used. The shoulders and upper limb extremities (including wrists and hands) were taught on day 1 of the course, and the hips and lower limb extremities (including knees, ankles and feet) were taught on day 2 of the course. On average, 4 h were focused on hands-on sonoanatomical aspects and a further 3 h on anatomical dissection and demonstration.

The faculty included expert anatomists and orthopaedic consultants for the dissection sessions and interventional radiologists and sports physicians for the injection techniques and sonoanatomy sessions. A list of relevant and clinically significant areas to be identified was given to the dissection faculty and participants before the session (Table 1), but the programme allowed for some flexibility during dissection, taking into account the learners' needs and areas of interest.

The anatomy suite at Singapore General Hospital adhered to the code of conduct and license from the Human Tissue Authority with respect to the use and disposal of human tissue regulated by the Human Tissue Act. The course was non-profit, endorsed by the Singapore Society of Rheumatology and designed purely for educational purposes. The total cost per attendee to run this course over 2 days was SGD $1000.

Questionnaire survey and pre- and post-course assessment

Pre- and post-course questionnaires were administered to participants (Supplementary Data S1 and S2, available at *Rheumatology Advances in Practice* online). A list of 20 pertinent anatomical areas was assembled by an organizing faculty member (M.M.) and independently reviewed for face validity by two other rheumatologists. Consequently, 18 questions (Supplementary Data S3, available at *Rheumatology Advances in Practice* online) were selected to cover all 10 anatomical areas. The objectives were to assess the anatomical knowledge of the candidates and evaluate their confidence in

Table 1 Guide for dissection: list of relevant anatomical areas

Shoulder	Wrist	Hand
Long and short head of biceps	Extensor retinaculum	Flexor digitorum profundus and superficialis
Subscapularis tendon	Extensor tendon compartments (I–VII)	Volar plate
Deltoid muscle	Carpal tunnel	Pulleys
Corocoid process	Proximal carpal tunnel	
Supraspinatus tendon	Distal carpal tunnel	
Subdeltoid bursa	Volar wrist ligaments	
Infraspinatus tendon	Scapholunate ligament	
Teres minor	Long and short radiolunate ligaments	
Transverse humeral ligament	Dorsal wrist ligaments	
Coracoacromial ligament	Scapholunate ligament	
Coracohumeral ligament	Dorsal intercarpal ligament	
Rotator interval	Radiotriquetral ligament	
	Triangular fibrocartilage, ulnocapitate and ulnolunate ligaments, meniscal homologue	
Knee	**Ankle**	**Foot**
Quadriceps tendon	Flexor retinaculum	Flexor hallucis longus
Suprapatellar recess	Anterior ankle tendons	Flexor digitorum longus
Patellar tendon	Tibialis tendon	Plantar aponeurosis
Pes anserinus	Extensor digitorum	Metatarsophalangeal joint
Medial collateral ligament	Extensor hallucis longus	Plantar plates
Lateral collateral ligament	Medial ankle tendons	
Biceps femoris	Tibialis posterior	
Gerdy's tubercle	Flexor digitorum	
Popliteus tendon	Flexor hallucis longus	
Gastrocnemius	Lateral ankle tendons	
Infrapatellar fat pad	Peroneal tendons and superficial peroneal retinaculum	
Popliteal artery	Deltoid ligament	
Tibial nerve	Spring ligament	
Common fibular nerve	Anterior talofibular ligament	
	Soleus	
	Achilles tendon	
	Kager's fat pad	

identifying sonoanatomical structures and performing US-guided interventions as a result of attending the course. The faculty ensured that the pre-test questions were not discussed during the course. Ethics approval for waiver of consent was obtained for the study, (NHG DRSB 2018/00263). Personal data and responses of the course attendees completing the questionnaire were anonymised.

Data and statistical analysis

Data were collected and interpreted manually from the online questionnaire, after which descriptive data analysis was performed using SPSS v.23.0. Means were calculated from the numerical percentage rating scales, and Student's paired *t*-test was used to compare the before and after scores in identifying surface anatomy, identifying sonoanatomy structures and performing IA injections.

Results

Prior anatomical knowledge

Seventeen attendees completed the pre- and post-course questionnaires, all of whom practised musculoskeletal US on a weekly basis. Fourteen (83.3%) felt that the anatomy teaching they received during their rheumatology postgraduate training was either somewhat inadequate or inadequate, and 13 (76.5%) felt that their current anatomical knowledge was either somewhat inadequate or inadequate. With regard to knowledge of sonoanatomy, 13 (76.5%) attendees felt that their knowledge was either somewhat inadequate or inadequate. Despite this, all attendees responded that their practice of US had improved their knowledge of anatomy, clinical examination skills and diagnostic skills.

Overall perceptions on use of human cadavers and dissection component

None of the attendees had previously attended a sonoanatomy course that incorporated dissection. Scanning of the cadaveric specimens followed by dissection was felt to be a useful way of learning anatomy and sonoanatomy, with 13 (76.5%) strongly agreeing and 4 (23.5%) agreeing. Most of the attendees responded that the cadaver-style learning compared very positively with previous forms of training, with respect to personal engagement, technical demonstration and efficiency of learning. With regard to the usefulness of the dissection component of the course

TABLE 2 List of anatomical and sonoanatomical knowledge items answered correctly during the pre-and post-course quiz

Item	Pre-workshop ($n = 15$)		Post-workshop ($n = 15$)		*P*-value
	Number	Percentage	Number	Percentage	
Iliotibial band	6	40	11	73	0.180
Pes anserine	7	47	14	93	0.016
Carpal tunnel boundaries	11	73	14	93	0.250
Flexor wrist tendons	11	73	14	93	0.250
Coracohumeral ligament	2	13	11	73	0.004
Superior glenohumeral ligament	2	13	8	53	0.031
Extensor tendons II	9	60	10	67	1.000
Extensor tendons V	9	60	15	100	–
Extensor tendons VI	11	73	15	100	–
Volar plates	5	33	7	47	0.687
Anterior inferior tibiofibular ligament	3	20	9	60	0.031
Anterior tibiofibular ligament	11	73	11	73	1.000
Soleus	4	27	14	93	0.002
Achilles tendon	15	100	14	93	–
Retrocalcaneal bursa	10	67	14	93	0.125
Kager's fat pad	9	60	13	87	0.125

P-value based on McNemar's test; (–) McNemar test was not valid.

in daily practice of musculoskeletal US and in understanding sonoanatomy, all of the attendees responded that it was either extremely useful or very useful.

Confidence levels pre- and post-course

After the course, the mean confidence rating in identifying surface anatomy increased by 1.85 (±1.3 S.D.), the mean confidence rating in performing IA injections increased by 1.54 (±1.3 S.D.), and the mean confidence rating in recognizing sonoanatomical structures increased by 1.77 (±1.2 S.D.). This was statistically significant ($t = 5.196$, $P < 0.001$; $t = 4.382$, $P = 0.001$; and $t = 5.165$, $P < 0.001$, respectively).

Anatomical and sonoanatomical knowledge pre- and post-course

Table 2 shows the numbers and percentages of respondents ($n = 15$) who correctly answered the questions related to anatomical and sonoanatomical areas based on the pre-course and post-course quizzes. The regions that showed greatest improvement in knowledge were the shoulder (rotator cuff interval), knee and ankle. Correct answers pertaining to the pes anserinus, coracohumeral ligament, superior glenohumeral ligament, anterior inferior tibiofibular ligament and soleus increased from 47 to 93% ($P = 0.016$), from 13 to 73% ($P = 0.004$), from 13 to 53% ($P = 0.031$), from 20 to 60% ($P = 0.031$) and from 27 to 93% ($P = 0.002$) respectively. Although there was a trend towards an increase in knowledge in other areas (wrist), this was not statistically significant.

Summary of qualitative data

The key themes that emerged included: positive feedback on the relevance of the dissection component; relationship of gross anatomy to the US findings; new approaches to injection techniques; knowledgeable and experienced tutors; adequate hands-on practice; interactive teaching methodology; and relevance to pathology seen in clinical practice. Scanning followed by dissection enabled the visualization of a three-dimensional map of the relevant regions, producing clarity in understanding the regional, relational and functional anatomy and relating it to sonoanatomy. The attendees benefited from being taught in an interactive manner and found that both the group and peer learning with a multidisciplinary faculty incorporating anatomists, orthopaedic surgeons, sports physicians and interventional radiologists were rewarding.

Comments included:

> '...the most useful component of the course was dissection of joints and related structures by experienced tutors';
> 'By seeing gross anatomy, I am able to better understand and recognize structures in sonoanatomy...';
> 'Scanning structures followed by the dissection helped consolidate my knowledge of anatomical course, attachments and function.... I can link sonanatomy better to the pathology';
> 'Practising probe–needle alignment in human cadavers while scanning was great as it gave me a better understanding of relational structures and realistic feeling of needle progression'; and
> 'Learnt a lot from faculty ... good to have a mix of disciplines'.

Discussion

Our study demonstrated that the majority of respondents felt that the teaching of musculoskeletal anatomy was suboptimal during their postgraduate rheumatology

training and that their knowledge of anatomy fell short of expectation, despite the fact that all used US in daily clinical practice. Although this perceived deficit was felt to have a negative impact on knowledge of sonoanatomy, respondents thought their US practice and upskilling had resulted in an overall improvement in their knowledge of anatomy, clinical examination and diagnostic skills.

The level of confidence of the attendees indicated significant improvements in terms of identifying surface anatomy, performing IA injections and recognizing sonoanatomy. The percentage of correct answers for each of the anatomical items, in particular the shoulder, knee and ankle, improved post-course, suggesting that a hands-on workshop, adopting an interactive methodology, strengthens the knowledge base of the learners. Areas that showed poor knowledge pre-course included the rotator cuff interval/biceps pulley system and the knee. Given that shoulder, (specifically, rotator cuff pathology) and knee complaints form a significant proportion of musculoskeletal referrals, implications of poor anatomical knowledge among rheumatologists in these areas might lead to inaccurate/incomplete diagnoses.

Limitations

The major limitations of this study include the small sample size of rheumatologists, attending a single-centre educational course. The small sample size might have accounted for the lack of statistical significance in some of the anatomical items tested in the pre- and post-course assessments that showed a trend towards an increase in knowledge.

Further limitations included the lack of formal validation of the pre- and post-course assessments, the small number of anatomical items assessed and the lack of more longer-term validity. Increasing the number of items assessed might be counterproductive, because it would shorten the time devoted to the workshop. Organizing another post-course assessment 4–5 weeks after the course would have ensured longer-term validity.

The attendees of this course all had prior expertise in US and were therefore likely to have more advanced knowledge of anatomy and greater awareness of their deficiencies compared with rheumatologists with no US experience. Future courses should be designed to address the needs of rheumatologists both with and without US experience, with appropriate standards for both groups.

Conclusion

In summary, it appears that the teaching of musculoskeletal anatomy is neglected in rheumatology teaching programmes. This study shows that the dual approach of US scanning complemented by the dissection of fresh human cadavers is very useful in increasing the confidence and anatomical knowledge of rheumatologists. We feel that cadaveric learning can and should be integrated into the post-graduate setting and that such workshops run by a multidisciplinary faculty are not only feasible, but also a valuable educational initiative for rheumatologists. Three-dimensional anatomical models and anatomical specimen maps can be used as an adjunct to support such cadaveric courses. Every rheumatologist, particularly those practising US, needs a good knowledge of anatomy in order to diagnose and manage MSK soft tissue pathology in a cost-conscious, effective manner.

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