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**Article:**

Malik-Tabassum, K, Lamb, JN, Chambers, A et al. (3 more authors) (Cover date: July–August 2020) Current State of Undergraduate Trauma and Orthopaedics Training in United Kingdom: A Survey-based Study of Undergraduate Teaching Experience and Subjective Clinical Competence in Final-year Medical Students. *Journal of Surgical Education*, 77 (4). pp. 817-829. ISSN 1931-7204

<https://doi.org/10.1016/j.jsurg.2020.02.015>

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**Title:**

Current state of undergraduate Trauma and Orthopaedics training in United Kingdom: a survey-based study of undergraduate teaching experience and subjective clinical competence in final-year medical students.

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**Keywords:**

Orthopedics, Trauma, Student Education, Learning Environment, Undergraduate Training, Medical School

## **ABSTRACT**

### **Objective:**

To assess the quality and duration of trauma and orthopaedics (T&O) training in medical schools in United Kingdom (UK), and to evaluate final-year students' self-perceived level of competence in essential T&O skills.

### **Design:**

This was a survey-based study of final-year medical students that attended one-day undergraduate T&O courses held between Feb'17 and Feb'19. Outcome measures were duration and perceived quality of undergraduate T&O placements, students' self-rated competence in essential T&O skills, and impact of teaching methods on their subjective future competence.

### **Setting:**

Four courses held at education centres in three different locations in UK (London, Nottingham, and Leeds)

### **Participants:**

All 414 course attendees from 13 UK medical schools completed the questionnaire.

### **Results:**

19.3% of students had not experienced a placement in T&O. Mean duration of T&O placements was 2.5 weeks. 37.4% described their training as "poor". Majority of students attended 1-5 sessions of: lectures (50.5%), small group teaching (58.7%), trauma meetings (58.7%), clinics (65.7%), and theatres (72.5%). Lowest competency scores were reported in management of T&O emergencies, fracture management, and interpretation of T&O radiographs. Self-rated competence in essential T&O skills was significantly higher in students with previous experience of a T&O placement ( $p < 0.05$ ). There was a strongly positive correlation between small group teaching attendance and perceived competence in management of T&O patients in different clinical settings ( $p < 0.001$ ).

### **Conclusions:**

Medical schools in UK are currently failing to adequately train medical graduates to manage T&O patients, with students reporting low competency scores in all basic T&O skills. To mitigate the current situation, a minimum duration of a T&O placement for all students must be implemented nationally. Educational boards and medical schools must work in collaboration to improve the delivery of undergraduate T&O curriculum, the structure of the clinical T&O placement, and efficacy of the commonly encountered learning environments.

### **ACGME competencies:**

Orthopedics, Trauma, Student Education, Learning Environment, Developing Individual Competence, Programme Evaluation in Medical Education

## INTRODUCTION

According to the report published by Arthritis Research UK in 2018, an estimated 28.9% of the United Kingdom (UK)<sup>1</sup> population was living with musculoskeletal conditions.

Musculoskeletal conditions are the leading cause for physical disability, chronic pain, and absence from work due to sickness<sup>1,2</sup>. They represent the most common cause for presentation to accident and emergency (A&E)<sup>2</sup>, and account for 30% of all primary care consultations. The delivery of musculoskeletal care is spread across a spectrum of specialities including trauma and orthopaedics (T&O)<sup>3</sup>, rheumatology, paediatrics, general medicine, emergency medicine, and general practice (GP). Therefore, irrespective of future speciality choice, it is imperative that medical students gain basic understanding of common T&O conditions, and feel competent in managing these patients upon graduation.

In 2014, British Orthopaedic Association published the undergraduate T&O syllabus to guide the provision of teaching in medical schools, and outline the expected level of knowledge and competencies required of a newly qualified medical graduate. T&O education and training in UK medical schools has been criticised, with significant disparity noted between the prevalence of T&O conditions and the time dedicated to clinical attachment in T&O. Undergraduate T&O training in the UK is mainly delivered during students' clinical rotation, often in conjunction with allied specialities such as rheumatology and A&E. Worryingly, in the last three decades, the average length of clinical attachment in T&O at UK medical schools has declined from 4.5 weeks to 2.65 weeks<sup>3-5</sup>. A study of 210 graduating UK medical students demonstrated that although 40% of students considered themselves competent in musculoskeletal medicine, only 21% passed the Freedman and Bernstein cognitive musculoskeletal examination<sup>4</sup>.

The primary aim of this study was to assess the quality of T&O training in UK medical schools, and to estimate students' self-rated competence in T&O. As a secondary aim, we explored the association between undergraduate T&O teaching methods and students' perceived future competence in T&O.

## MATERIAL AND METHODS

### Data Collection

Established in December 2013, CollabORTHO is a national teaching collaboration of T&O consultants and trainee doctors. CollabORTHO aims to improve undergraduate education and training in T&O through provision of free courses to final-year medical students across the UK. These courses were advertised nationally via social media platforms, medical school and orthopaedic society intranet pages, and by emailing university coordinators. Final-year medical students that registered to attend CollabORTHO courses between February 2017 and February 2019 were invited to complete an online pre-course questionnaire. Four courses were held during this two-year period at university hospital education centres in London, Nottingham and Leeds. All students consented to data collection and analysis of survey results. Results of the surveys were anonymised for further analysis.

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<sup>1</sup> United Kingdom = UK

<sup>2</sup> Accident and emergency = A&E

<sup>3</sup> Trauma and orthopaedics = T&O

<sup>4</sup> Conditional inference tree = Ctree

The questionnaire was designed using “Google Forms” (Google LLC, USA) (Table 1). In order to eliminate incomplete entries, all sections of the forms were made mandatory for completion. Depending on the nature of the question, the answers were provided as binary (yes/no), multiple choice, multiple grid, likert scale (1-10) or free text.

### **Data analysis**

All questionnaire items were included in data analysis. For simplicity, variables related to teaching exposure in undergraduate training (questionnaire item 7) were collapsed into binary variables (clinical placement/no clinical placement). Age was organised into three groups to improve clarity of non-linear results (“less than 24 years”, “24 and 25 years” and “26 years and older”), and overall T&O experience was organised into three groups (“Poor or less than adequate”, “Adequate” and “Good or excellent”).

To explore the current state of T&O teaching experience, teaching experience of all respondents was described. To determine the effect of clinical placement in T&O on the type and frequency of teaching exposure, respondents were split into groups according to whether they had a placement or not. The exposure to teaching methods and subjective assessment of overall T&O teaching experience was compared between these groups.

To summarise the current subjective perception of T&O clinical skills, responses relating to self-assessment of competence in T&O clinical skills (questionnaire item 6) were described. To understand the effect of a clinical placement on the subjective assessment of students’ current competencies in T&O clinical skills, the respondents were split into those who had a clinical T&O placement and those who did not; their subjective self-assessment of T&O clinical skills were then compared. The relationship between subjective estimates of competence in T&O were then explored with machine learning methods.

### **Statistical methods**

Normally distributed continuous variables were compared using two-way paired T-tests. Non-normally distributed continuous data were compared with a Mann-Whitney test. Categorical variables were compared using a Chi-squared test. Likert scale variables were treated as continuous data for the purposes of analysis. Conditional inference tree (Ctree)<sup>4</sup> analysis was used to assess the relationship between various modes of teaching and perceived competence in management of T&O patients in three different clinical settings (foundation T&O post, emergency care, and primary care). Ctree analysis is a form of machine learning that identifies factors which differentiate respondents between those with highest and lowest perceived future competence. The Ctree uses a variable to sequentially divide the participants into two subgroups; those with highest and lowest perceived competence. Then the Ctree continues to split each subgroup until there are no further statistically significant splits possible. Test results with a p-value of less than 0.05 were deemed significant. Splits are always performed with the most significant variable for each group of respondents and results are displayed in a tree diagram.

## **RESULTS**

### **Demographics**

All 414 course attendees completed the online survey. The respondents were final-year students from 13 UK medical schools. 39.4% of respondents were male (163/414) and 60.6% were female (251/414). Mean age [standard deviation, SD] of respondents was 23.9 years [2.4]. Majority (85.3%, 353/414) of students had no previous undergraduate qualifications prior to admission to medical school. 20.3% (84/414) of respondents expressed their interest in pursuing a career in T&O (Table 2).

### **Experience of undergraduate training**

19.3% (80/414) had no previous clinical T&O placement. For students who had previously undertaken a T&O placement, the most common duration of placement was four weeks (44%, 182/414). The average duration of T&O rotation for all students was 2.5 weeks (range, zero to five weeks) (Table 3).

15% (62/414) had never attended any theatre sessions or outpatient T&O clinics, 21.7% (90/414) had never received any small group tutorials, 35.3% (146/414) had not attended a single trauma meeting, and 40.6% (168/414) had not experienced any T&O on-call shifts under supervision. 91.5% (379/414) had previously received T&O teaching via formal lectures. The most frequent answer for attendance of all encountered teaching settings was “1 to 5” sessions i.e. lectures (50.5%, 209/414), small group teaching sessions (58.7%, 243/414), trauma meetings (58.7%, 243/414), outpatient clinics (65.7%, 272/414), and operating theatres (72.5%, 300/414). The majority of respondents had never been formally assessed in T&O (68.4%, 283/414). 24.4% (101/414) felt that undergraduate teaching was “Excellent” and 26.3% (109/414) regarded the teaching as “adequate”. The most frequent response to overall perception of undergraduate training was “poor” (37.4%, 155/414) (Table 3).

Respondents who had completed a rotation in T&O had significantly more exposure to all forms of teaching, and had undertaken formative assessments in T&O,  $p<0.001$  (Table 4).

### **Subjective competencies in T&O clinical skills**

Respondents reported highest mean [SD] subjective competency in T&O history (5.61 [2.08]), knee examination (5.76 [2.03]) and hip examination (5.48 [2.01]) (Figure 1). Lowest mean (SD) subjective competency was reported in management of T&O emergencies (4.45[1.91]), fracture management (4.73[1.98]), and interpretation of T&O radiographs (5.05[1.98])

For all described T&O skills, perceived competence among students who had undertaken a formal placement in T&O were significantly greater than those who had no previous clinical T&O placement,  $p<0.01$  (Figure 2).

### **Subjective future competence in management of T&O patients**

Respondents who had rotated through a formal clinical placement (334/414) during their undergraduate training were significantly more likely to report higher levels of perceived future competence in managing T&O patients in all described clinical settings  $p<0.01$  (Figure 3).

Future subjective competence in an emergency care (A&E) setting was highest in students who had received more than five small group teaching sessions. Among students who

received equal or less than five small group teaching sessions, teaching in trauma meetings and operating theatres was associated with higher perceived competence in managing T&O patients in A&E. The lowest future perceived competence in emergency T&O care was in students who had no small group, trauma meeting or operating theatre teaching (Figure 4). Future subjective competence in undertaking a foundation post in T&O in the hospital setting was greatest in students who had received small group tutorials, and then in those who attended outpatient T&O clinics (Figure 5). Future competence in caring for T&O patients in primary care (GP) setting was greatest in students who had attended more than five small group teaching sessions, and then in those who had attended T&O operating theatres (Figure 6).

## DISCUSSION

### What this study adds

This study represents the largest survey of final-year medical students in the UK assessing the length and quality of undergraduate T&O rotations. It is the first study to investigate students' subjective competence in essential T&O skills, and future subjective confidence in management of T&O patients in commonly encountered clinical settings near completion of their medical degrees. Furthermore, this is the first study to describe the relationship between undergraduate T&O teaching methods and students' perceived competence in T&O.

### Duration of T&O placement

The national annual cost of musculoskeletal care was estimated at £4.75 billion in 2013-14, with T&O procedures accounting for a quarter of all surgical interventions in the National Health Service. Due to our ageing population and increasing prevalence of obesity, the burden of musculoskeletal disease is predicted to worsen in the future<sup>6,7</sup>. In order to highlight and tackle the global burden of musculoskeletal disease, the period between 2000 and 2010 was designated as the 'Bone and Joint Decade' by the World Health Organisation<sup>8</sup>. One of its key aims was to make significant changes to medical school programmes globally, so that students receive at least six months of exposure to musculoskeletal training<sup>8</sup>.

This study shows that only 80.7% of students had undertaken an undergraduate T&O placement prior to graduating from medical school. Additionally, the average allocated time for T&O rotations was only 2.5 weeks. Taking into account the healthcare burden of musculoskeletal disorders, the demonstrated length of undergraduate T&O exposure is disproportionately small, and fails to meet the target set by the Bone and Joint Decade by a significant magnitude<sup>8</sup>. These findings are similar to previously published UK studies<sup>3-5</sup>.

### Quality of undergraduate T&O training

In UK, medical school is a five- or six-year programme followed by a mandatory two-year internship, also known as "Foundation Training". Although, the standards for undergraduate medical education are governed by the General Medical Council, each university has their own syllabus and uses different methods of teaching. Although, a proportion of the undergraduate curriculum may be delivered in a lecture room, clinical "attachment/rotation" in T&O at affiliated teaching hospitals remains the primary source of formal undergraduate

T&O training<sup>3</sup>. The structure of the clinical rotation in T&O may vary significantly between departments. Training during a T&O rotation is delivered in a wide variety of settings i.e. didactic lectures, small group tutorials, ward rounds, trauma meetings, outpatient clinics, and in the operating room<sup>5,9,10</sup>.

Our results (Table 4) indicate that the most frequent answer for attendance of all encountered teaching settings among respondent who had previously attended a formal T&O rotation was “1 to 5” sessions. Lecture based teaching appeared to be the most frequent teaching methods employed to deliver the T&O curriculum; a significantly greater proportion of students received “6 to 10” (29.9%) and “>10” (19.2%) lectures respectively when compared to other interactive teaching methods , i.e. small group teaching (20.1%, 3.3%), trauma meetings (4.5%, 2.1%), outpatient clinics (20.1%, 3.0%), and operating theatre (10.8%, 3.6%). Furthermore, among students who had not completed a rotation in T&O, 68.8% (55/80) had received “1 to 5” lectures.

Although, 44.6% (149/334) of students with previous experience of a T&O rotation rated their teaching as “poor” or “less than” adequate, a formal placement provided them with significantly higher exposure to all T&O learning environments, when compared to students with no previous clinical placement. Interestingly, a higher proportion of respondents with no previous T&O placement described their experience of undergraduate training as “Good” or “Excellent” when compared to those who had completed a rotation in T&O, i.e. 46.3% vs. 25.8% ( $p<0.001$ ). It is possible that students that had completed a T&O rotation were more likely to be dissatisfied with their experience because their learning objectives and expectations of a T&O placement were not met.

### **Assessment of T&O competencies**

In a study conducted by Al-Nammari *et al.*, only 21% of graduating medical students were deemed competent in musculoskeletal medicine using a validated Freedman and Bernstein basic cognitive musculoskeletal examination<sup>4</sup>. In this study, students were asked to rate their perceived clinical competence in key T&O skills such history taking, musculoskeletal examinations, interpretation of T&O radiographs, and management of common fractures and orthopaedic emergencies. Students reported low subjective competency scores in all described T&O skills. The self-rated competency scores for students who had undertaken a formal placement were significantly greater than those who had no previous T&O placement. This may be due to the fact that students who had completed a rotation in T&O had significantly more exposure to all forms of teaching. Additionally, higher probability of formative exams in T&O in this group of students may have acted as a further motivating factor for focused learning (Table 4).

Lowest subjective competency scores reported in management of fractures and orthopaedic emergencies raise strong concerns regarding graduating doctors’ future ability to manage T&O patients in A&E or during their on-call as a T&O foundation doctor. It is therefore vital that teaching of T&O and the diagnosis and management of musculoskeletal disease is incorporated into the “core” curriculum, and the view that T&O is solely a postgraduate subject is challenged and disregarded.

### **Link between teaching methods and future T&O competence**

In order to improve delivery of T&O education, it is important to understand factors that contribute to beneficial learning experience for students. The Ctree analysis provides us with a valuable insight into students' perception of learning opportunities, which is crucial in planning future education developments. Although, majority of respondents had attended T&O lectures, attendance of lectures was not associated with students' perceived competence in T&O. Results of the present study demonstrated a strong correlation between attendance of small group teaching sessions and improved subjective competence in caring for T&O patients in all three future clinical settings. Similar findings were also observed with other interactive learning environments such as outpatient clinics, trauma meetings, and operating theatres. This is consistent with the previously published studies, as interactive sessions have been reported as the most valuable to medical students<sup>9,11</sup>.

Trauma meeting are daily morning meetings held in majority of T&O departments in the UK<sup>10</sup>. Patients admitted during the "on-call" over the previous 24-hours and those requiring surgery are formally presented to the department. Trauma meetings are attended by T&O consultants, trainees, medical students and allied healthcare professionals such as trauma nurses, operating theatre coordinators, anaesthetists, and physiotherapists. These meetings facilitate case discussions, trauma list planning, encourage quality control, and serve the purpose of formal handover. Trauma meetings provide a valuable forum for education and training<sup>10</sup>. It is disappointing that over a third of participants in this study had not attended a single trauma meeting. This represents a wasted learning opportunity for a significant proportion of students attending T&O placements. Trauma meeting should be introduced as a frequent feature in students' timetable during their placements and their participation should be encouraged.

Exposure to operating is an important aspect of surgical teaching which was identified as a significant factor for future competence in both emergency medicine and GP. A&E doctors and general practitioners are the frontline physicians who are responsible for identification and timely referral of T&O patients requiring emergent surgical intervention. Attendance of trauma theatre lists provide students with the opportunity to learn about surgical emergencies in T&O in a more interactive and visual way. Additionally, exposing aspiring general practitioners to commonly performed elective orthopaedic procedures such as total hip and knee replacements would allow them to better explain these procedures to patients in their future clinical practice. This unique learning environment may also help students consolidate their previously gained textbook knowledge of anatomy, pathology and physiology. Furthermore, having a good experience in operating theatre as a student is shown to positively correlate with students' interest in pursuing a surgical career<sup>12</sup>. In order to gain the most from operating theatre opportunities, the student should be well prepared, felt welcomed and integrated into the team with an active, defined role with learning objectives clearly articulated throughout<sup>12-15</sup>.

### **Opportunities for post-graduate T&O training**

Following graduation, opportunities for post-graduate training in T&O for non-orthopaedic trainees are limited. The post-graduate UK foundation programme typically consists of six four-monthly placements in a broad range of specialities. The aim of this two-year postgraduate programme is to help medical graduates bridge the gap between medical school and higher training through delivery of a structured competency based curriculum<sup>16</sup>.

Several studies have demonstrated paucity of postgraduate T&O training in UK<sup>3,17,18</sup>. The 2016 UK foundation programme report showed that T&O rotations featured in only 31.5% of foundation programmes; 13.1% in year-1 and 18.4% in year-2. In contrast, 86.3% and 71.6% of foundation programmes contained placements in General Surgery and General Medicine respectively<sup>19</sup>. Similarly, UK GP Vocational Training have also been shown to have inadequate provision for T&O training<sup>18,20</sup>. Al-Nammari *et al.* showed that only 8.9% of foundation year-2 doctors passed the musculoskeletal cognitive test<sup>17</sup>. Therefore, with the exception of T&O speciality trainees, medical school remains the primary source of formal training in T&O for majority of clinicians. This study shows that nearly one-fifth of final-year medical student respondents had not completed a formal T&O placement during undergraduate training. It is of great concern that it is entirely conceivable for a medical graduate to become a fully qualified GP, paediatrician or an A&E physician without having undergone any formal T&O training at the undergraduate or postgraduate level.

### **Current political climate and suggestions for change**

Medical education in UK is complex and politically important. Over the last decade, several changes to methods of financing medical education have been made<sup>21</sup>. Currently, hospitals that provide clinical placements for medical students have a contract with medical schools and Local Educational Training Boards (LETB). They receive funding via Service Increment for Training, SIFT (part of National Health Service (NHS) budget). Given the fact that there has been a steady reduction in the tariff for undergraduate medical education over the last 3 years, it is increasingly important that teaching hospitals demonstrate transparency in how their funding is supporting the delivery of the undergraduate curriculum<sup>21,22</sup>. In order to justify allocation of educational funding to the T&O departments, undergraduate departmental leads must take necessary steps to improve the quality of undergraduate T&O training. Undergraduate placements in T&O should be reserved for hospitals with reputation for teaching excellence and added educational support should be provided to students who rotate through hospitals that are under pressure to meet service demands.

Following the release of “Shape of Training” report, Foundation Schools were urged to move away from “speciality training” to more “broad based” training, therefore, incorporating more community based rotations such as GP and psychiatry in the foundation programme at the expense of hospital based specialities including T&O<sup>19,23</sup>. Hence, it is inevitable that medical schools will start to favour more community based teaching in order to prepare their students for life after graduation. Universities are increasingly under pressure to deliver and streamline the undergraduate curriculum to produce an ever-increasing number of “broadly trained” medical graduates<sup>24</sup>. Whilst increasing the length of undergraduate T&O rotation may seem desirable, this may not be feasible due to increasing number of students, conflicting interests from other specialities, clinicians’ service commitments, and time constraints. Therefore, in order to optimise students’ learning, universities should focus their efforts in improving curriculum design, structure of the clinical attachment, and efficacy of the commonly encountered learning environments<sup>25</sup>. It is possible that more effective teaching can be achieved within the current educational constraints; by substituting the traditional didactic lecture-based teaching with more dynamic and interactive teaching methods that have superior educational value.

### **Limitations**

The authors are aware of the limitations of this study. This study is based on a retrospective observational dataset and the findings represent associations, which may help to develop useful hypotheses, but do not represent causation. Although our questionnaires were issued in the latter part of the UK academic year, it is possible that some of these students were yet to start their T&O placement, making underestimation of T&O teaching provision more likely. Although the response rate was 100%, figures published by “The Foundation Programme Annual Report 2016” suggest that the student cohort in this study represents only 2.8% of all UK medical graduates over a 2-year period<sup>19</sup>. However, this study still represents over one-third (13/31) of all UK medical schools. Additionally, the demographics of the studied cohort is similar to UK medical schools i.e. 39% male and 61% female in this study vs. 45% male and 55% female in all UK medical schools<sup>26</sup>. Given that majority of UK medical school entrants are under the age of 20, the average age of our respondents (23.9 years [2.4]) is also representative of final-year medical students in UK<sup>27</sup>.

This course was advertised nationally via social media platforms, speciality specific society websites and by contacting course administrators to ensure all UK final-year students were reached. The study population may represent students that felt that their undergraduate training in T&O was inadequate and lead to an over-representation of students with poorer perceptions of teaching and competence. Students may have reported low competency scores in order to highlight the value of the course, potentially resulting in reporting bias. Conversely, this study included a large proportion of those with a particular interest in pursuing T&O as a career i.e. 20.3% in this study vs. 3.1% (*Goldacre et al*), which may have led to a more positive view of T&O teaching provision<sup>28</sup>. Despite the national nature of these courses i.e. courses were held in the North (Leeds), Midlands (Nottingham) and South of England (London), students located closer to the course venues may have been more inclined to attend the courses. Recall bias may have led to error in the accuracy of results, which we are unable to confirm without objective ratification of questionnaire results. Students were asked about their perceived competence in T&O, but no objective assessment tool was administered. Although objective assessment tools are valuable, test scores alone may not truly reflect students’ true skills and attributes required to become competent and confident physicians<sup>4</sup>.

## **CONCLUSIONS:**

Our study shows that provision of T&O training varies between universities, with significant proportion of students reporting their undergraduate T&O training to be inadequate or poor. There is still a slow decline in the number of weeks devoted to undergraduate T&O training. Despite these findings, the current undergraduate teaching programme in UK medical schools has some benefits, as students who previously attended T&O placements reported significantly higher level of perceived competence in T&O when compared to those who did not. Delivery of training in interactive learning environments such as small group session, outpatient clinics, operating theatres, and trauma meeting are associated with improved learning experience and significantly higher subjective competence. The disparity in length and quality of the T&O rotation in UK medical schools should be addressed with implementation of a standardised musculoskeletal curriculum nationally. Future studies should focus on assessing students’ pre- and post-course subjective, as well as objective competency using validated objective assessment. A national survey of UK medical schools to investigate the difference in curriculum delivery between institutions, and ways to improve

students' experience of T&O training would be useful to ensure accuracy of future educational planning.

## **STATEMENTS:**

**Ethical approval:** Not required.

**Acknowledgements:** We thank our CollabORTHO colleagues for their help in organising and delivering national teaching courses to final-year medical students.

**Funding sources:** This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

**Declaration of interest:** None.

**Data statement:** Due to the nature of questions asked in this study, survey respondents were assured raw data would remain confidential and would not be shared.

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## TABLES:

**Table 1: Questionnaire items**

1. Gender: (male/female/transgender)	8. What was the duration of your previous clinical placement(s) in T&O (number of weeks)? (NB: Please do not include the duration of Rheumatology placement)
2. Age: (years)	9. Please answer the following questions:
3. Did you have any other undergraduate qualifications prior to commencing a medical degree? (yes/no)	<ol style="list-style-type: none"> <li>How many T&amp;O lectures have you received during medical school? (0, 1-5, 6-10, &gt;10)</li> </ol>
4. If the answer to the above question is Yes, please state your undergraduate qualification: (free text)	<ol style="list-style-type: none"> <li>How many bedside or informal small group teaching sessions have you received during your T&amp;O placement(s)? (0, 1-5, 6-10, &gt;10)</li> </ol>
5. Are you planning a career in T&O? (yes/no)	<ol style="list-style-type: none"> <li>How many trauma meetings have you attended during your T&amp;O placement(s)? (0, 1-5, 6-10, &gt;10)</li> </ol>
6. How competent do you feel in performing the following? (1 = incompetent, 10 = fully competent)	<ol style="list-style-type: none"> <li>How many clinics have you attended during your T&amp;O placement(s)? (0, 1-5, 6-10, &gt;10)</li> </ol>
i. History taking in T&O	<ol style="list-style-type: none"> <li>How many times have you attended T&amp;O theatres? (0, 1-5, 6-10, &gt;10)</li> </ol>
ii. Hand examination	<ol style="list-style-type: none"> <li>How many shifts have you spent shadowing the T&amp;O on-call team? (0, 1-5, 6-10, &gt;10)</li> </ol>
iii. Shoulder examination	
iv. Spine examination	
v. Hip examination	
vi. Knee examination	
vii. Presenting examination findings	10. Have you previously received any formative assessments in T&O?
viii. Interpreting and presenting T&O radiographs	(yes/no)
ix. Basic fracture management	
x. Management of T&O emergencies	11. How would you rate your experience of
xi. Undertaking a foundation post in T&O	
xii. Management of T&O patients in emergency care (A&E)	
xiii. Management of T&O patients in primary care (General Practice)	

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7. Have you previously undertaken a clinical placement in T&O? (yes/no)	undergraduate training in T&O?
	a. Excellent
	b. Good
	c. Adequate
	d. Less than Adequate
	e. Poor

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<b>Table2:</b> Baseline demographics of respondents		
Total respondents (%)		414 (100)
Gender (%)	<i>Female</i>	251 (60.6)
	<i>Male</i>	163 (39.4)
Age (mean [SD])		23.9 (2.4)
Previous undergraduate qualifications (%)	<i>None</i>	353 (85.3)
	<i>BA</i>	5 (1.2)
	<i>BDS</i>	2 (0.5)
	<i>BEng</i>	2 (0.5)
	<i>BSc</i>	48 (11.6)
	<i>MSc</i>	2 (0.5)
Interest in pursuing a career in T&O (%)	<i>No</i>	330 (79.7)
	<i>Yes</i>	84 (20.3)

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<b>Table 3:</b> Survey results demonstrating exposure to undergraduate T&O education and training		
n		414
Clinical placement in T&O duration (%)	<i>No placement</i>	80 (19.3)
	<i>1 week</i>	28 ( 6.8)
	<i>2 weeks</i>	95 (22.9)
	<i>3 weeks</i>	23 ( 5.6)
	<i>4 weeks</i>	182 (44.0)
	<i>5 weeks</i>	6 ( 1.4)
Lecture attendance (%)	<i>0</i>	35 ( 8.5)
	<i>1 to 5</i>	209 (50.5)
	<i>6 to 10</i>	106 (25.6)
	<i>&gt;10</i>	64 (15.5)
Small group teaching attendance (%)	<i>0</i>	90 (21.7)
	<i>1 to 5</i>	243 (58.7)
	<i>6 to 10</i>	70 (16.9)
	<i>&gt;10</i>	11 ( 2.7)
Trauma meeting attendance (%)	<i>0</i>	146 (35.3)
	<i>1 to 5</i>	243 (58.7)
	<i>6 to 10</i>	17 ( 4.1)
	<i>&gt;10</i>	8 ( 1.9)
T&O outpatient clinic attendance (%)	<i>0</i>	62 (15.0)
	<i>1 to 5</i>	272 (65.7)
	<i>6 to 10</i>	70 (16.9)
	<i>&gt;10</i>	10 ( 2.4)
T&O operating theatre attendance (%)	<i>0</i>	62 (15.0)

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	<i>1 to 5</i>	300 (72.5)
	<i>6 to 10</i>	39 ( 9.4)
	<i>&gt;10</i>	13 ( 3.1)
Number of shift shadowing on-call T&O team (%)	<i>0</i>	168 (40.6)
	<i>1 to 5</i>	230 (55.6)
	<i>6 to 10</i>	15 ( 3.6)
	<i>&gt;10</i>	1 ( 0.2)
Formative T&O assessments (%)	<i>No</i>	283 (68.4)
	<i>Yes</i>	131 (31.6)
Undergraduate experience of T&O training (%)	<i>Poor</i>	155 (37.4)
	<i>Less than Adequate</i>	27 ( 6.5)
	<i>Adequate</i>	109 (26.3)
	<i>Excellent</i>	101 (24.4)
	<i>Good</i>	22 ( 5.3)

**Table 4:** Comparison of teaching exposure in students who had a formal placement in T&O vs. no previous placement

		Previous placement	No previous placement	p-value
n		334	80	
Lecture attendance (%)	<i>0</i>	16 ( 4.8)	19 ( 23.8)	<0.001
	<i>1 to 5</i>	154 ( 46.1)	55 ( 68.8)	
	<i>6 to 10</i>	100 ( 29.9)	6 ( 7.5)	
	<i>&gt;10</i>	64 ( 19.2)	0 ( 0.0)	
Small group teaching attendance (%)	<i>0</i>	45 ( 13.5)	45 ( 56.2)	<0.001
	<i>1 to 5</i>	211 ( 63.2)	32 ( 40.0)	
	<i>6 to 10</i>	67 ( 20.1)	3 ( 3.8)	
	<i>&gt;10</i>	11 ( 3.3)	0 ( 0.0)	
Trauma meeting attendance (%)	<i>0</i>	88 ( 26.3)	58 ( 72.5)	<0.001
	<i>1 to 5</i>	224 ( 67.1)	19 ( 23.8)	
	<i>6 to 10</i>	15 ( 4.5)	2 ( 2.5)	
	<i>&gt;10</i>	7 ( 2.1)	1 ( 1.2)	
T&O clinic attendance (%)	<i>0</i>	10 ( 3.0)	52 ( 65.0)	<0.001
	<i>1 to 5</i>	247 ( 74.0)	25 ( 31.2)	
	<i>6 to 10</i>	67 ( 20.1)	3 ( 3.8)	
	<i>&gt;10</i>	10 ( 3.0)	0 ( 0.0)	
T&O operating theatre attendance (%)	<i>0</i>	20 ( 6.0)	42 ( 52.5)	<0.001
	<i>1 to 5</i>	266 ( 79.6)	34 ( 42.5)	
	<i>6 to 10</i>	36 ( 10.8)	3 ( 3.8)	
	<i>&gt;10</i>	12 ( 3.6)	1 ( 1.2)	
Shadowing on-call T&O team (%)	<i>0</i>	110 ( 32.9)	58 ( 72.5)	<0.001
	<i>1 to 5</i>	211 ( 63.2)	19 ( 23.8)	
	<i>6 to 10</i>	12 ( 3.6)	3 ( 3.8)	
	<i>&gt;10</i>	1 ( 0.3)	0 ( 0.0)	
Formative T&O assessments (%)	<i>No</i>	210 ( 62.9)	73 ( 91.2)	<0.001
	<i>Yes</i>	124 ( 37.1)	7 ( 8.8)	
Undergraduate experience of T&O	<i>Poor</i>	124 ( 37.1)	31 ( 38.8)	<0.001

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training (%)			
	<i>Less than Adequate</i>	25 ( 7.5)	2 ( 2.5)
	<i>Adequate</i>	99 ( 29.6)	10 ( 12.5)
	<i>Good</i>	12 ( 3.6)	10 ( 12.5)
	<i>Excellent</i>	74 ( 22.2)	27 ( 33.8)

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## FIGURE CAPTIONS:

**Figure 1:** Perceived competence in T&O skills

**Figure 2:** Comparison of perceived competence in T&O skills between respondents who had a formal placement in T&O vs. no previous placement

**Figure 3:** Comparison of perceived competence in management of T&O patients between respondents who had a T&O placement vs. no previous placement

**Figure 4:** Ctree diagram demonstrating association between mode of teaching and perceived competence in management of T&O patients in A&E

**Figure 5:** Ctree diagram demonstrating association between mode of teaching and perceived competence in undertaking a foundation post in T&O

**Figure 6:** Ctree diagram demonstrating association between mode of teaching and perceived competence in management of T&O patients in primary care (general practice)