



■ GENERAL ORTHOPAEDICS

Design and implementation of an acute Trauma and Orthopaedic ePlatform (TOP) referral system utilising existing secure technology during the COVID-19 pandemic

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Introduction

Virtual fracture clinics (VFCs) are being increasingly used to offer safe and efficient orthopaedic review without the requirement for face-to-face contact. With the onset of the COVID-19 pandemic, we sought to develop an online referral pathway that would allow us to provide definitive orthopaedic management plans and reduce face-to-face contact at the fracture clinics.

Methods

All patients presenting to the emergency department from 21 March 2020 with a musculoskeletal injury or potential musculoskeletal infection deemed to require orthopaedic input were discussed using a secure messaging app. A definitive management plan was communicated by an on-call senior orthopaedic decision-maker. We analyzed the time to decision, if further information was needed, and the referral outcome. An analysis of the orthopaedic referrals for the same period in 2019 was also performed as a comparison.

Results

During the study period, 295 patients with mean age of 7.93 years (standard error (SE) 0.24) were reviewed. Of these, 25 (9.8%) were admitted, 17 (5.8%) were advised to return for planned surgical intervention, 105 (35.6%) were referred to a face-to-face fracture clinic, 137 (46.4%) were discharged with no follow-up, and seven (2.4%) were referred to other services. The mean time to decision was 20.14 minutes (SE 1.73). There was a significant difference in the time to decision between patients referred to fracture clinic and patients discharged (mean 25.25 minutes (SE 3.18) vs mean 2.63 (SE 1.42); $p < 0.005$). There were a total of 295 referrals to the fracture clinic for the same period in 2019 with a further 44 emergency admissions. There was a statistically significant difference in the weekly referrals after being triaged by the VFC (mean 59 (SE 5.15) vs mean 21 (SE 2.17); $p < 0.001$).

Conclusion

The use of an electronic referral pathway to deliver a point of care virtual fracture clinic allowed for efficient use of scarce resources and definitive management plan delivery in a safe manner.

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Introduction

Trauma and Orthopaedic Surgery performs the greatest volume of outpatient reviews in Ireland with almost 400,000 outpatient attendances per annum.¹ The fracture clinic makes up a significant proportion of these

attendances, and often the demands placed on the fracture service outstrip the available capacity. Delays in the initiation of appropriate management plans may adversely affect outcomes.²

Virtual fracture clinics (VFCs) have emerged as a novel, efficient, and cost-effective way of managing stable fractures which do not require ongoing orthopaedic intervention.²⁻⁶ They offer the ability for the orthopaedic service to remotely review and advise on injuries without the requirement for face-to-face outpatient visits. In our institution, a paediatric university hospital, the fracture and elective clinics run concurrently. The VFC had previously been demonstrated to reduce numbers in the outpatient setting, therefore, allowing for an increase in elective outpatient capacity.⁷

In institutions which have implemented VFCs, the reported reduction in fracture clinic workload is 22% to 33%.^{6,7} Others have similarly reduced the average number of outpatient attendances per fracture from 1.76 to 0.17– 0.3 attendances.^{4,8} There are significant social effects of attending a fracture clinic with Breathnach et al⁹ demonstrating that 68% of the patients seen in the VFC would have had to take time off work to attend the fracture clinic and Morris and Bell¹⁰ showing that for every 100 attendances there were 54 days of school and 25 days of work lost. In the paediatric setting, the impact on education from missed school days is a particularly important factor.

The British Orthopaedic Association Standards for Trauma (BOAST) guidelines recommend that every new referral to the fracture clinic is seen within 72 hours of referral.¹¹ VFCs offer the potential to achieve BOAST compliance by having a senior orthopaedic decision-maker review referrals and make appropriate onward management plans.¹² The VFC also allows for the removal of inappropriate or unnecessary referrals to the fracture clinic.² Up to 15% of all referrals to the fracture clinic are unnecessary,¹³ and our institution demonstrated 37% of fracture clinic referrals had no radiological evidence of fracture, and 25% of the fractures required no formal orthopaedic review.¹⁴ Other institutions have shown that up to 47% of referrals do not have definite evidence of a fracture.¹⁵ Removing these patients from the fracture clinic reduces waiting times for patients while maintaining patient-reported satisfaction scores from 78% to 98%.^{4,6,8,16-19}

Changing the structure of any established service is difficult and involves input from multiple stakeholders,²⁰ which can be fraught with planning difficulties. With the onset of the COVID-19 pandemic and the resulting cessation of all but essential outpatient activities and the requirement to reduce face-to-face contacts given the disease transmission mechanism, this offered a unique situation that required a technological solution.

The VFC model used at other sites was not implementable at our unit as we were unable to recruit senior nursing staff and physiotherapists, or have dedicated VFC times given the pandemic status. Therefore, a specific technological solution for our institution was designed

using pre-existing technology, which we termed the Trauma and Orthopaedics ePlatform (TOP). Siilo (Siilo, Amsterdam, the Netherlands), a secure health care communication app which allowed for the discussion of cases in real-time, was identified. Clinical information, examination findings, and imaging were provided in a standard format on the online platform and a definitive plan set in place. Patients were admitted, discharged, given a date for planned day of surgery admission (DOSA) or brought for a face-to-face contact fracture clinic based on their TOP information. All patients were provided with a fracture specific information leaflet on discharge from the emergency department, and a copy of the ePlatform conversation uploaded to their electronic patient record.

We hypothesised that the use of TOP would result in a reduction in fracture clinic attendances, a reduction in the time taken to provide definitive management plans, and a higher discharge rate of stable fractures. We also believed this would be associated with a reduction in missed school days and loss of earnings for referred patients without an increase in complications or resources.

Methods

The aim was to explore a potential virtual solution that encompassed the safe discharge of patients from our emergency department (ED). A current patient flow map for potential orthopaedic trauma patients was constructed (Figure 1). By analyzing the pathway, applying a Lean methodology²¹ and utilizing an electronic platform, we were able to formulate a new referral approach for all orthopaedic presentations to the ED. These changes had to be implemented with no additional resources in a time-sensitive manner due to the COVID-19 pandemic that was driving change.

On 21 March 2020, all referrals to the fracture clinic were moved to the technological platform. A group discussion for all orthopaedic and ED medical teams was constructed. All referrals were made via this platform to senior on-call orthopaedic decision-makers (orthopaedic registrar and consultant). A secure communication app Siilo was identified. It complies with the General Data Protection Regulation (GDPR),^{22,23} has an interface that is intuitive to a new user, requires no additional training, and can structure referral messages into case files which are exportable as a PDF to the patients' electronic patient record. Participants in the TOP group were added by consultants in emergency medicine and orthopaedic surgery, maintaining a closed network communication group. A new process map was constructed to represent this change and is presented in Figure 2. Any patient who the ED team felt required orthopaedic review was discussed using the TOP. There were 295 total referrals made in the period. 168 (56.95%) of these referrals were female patients, and 127 male (43.05%). The mean age was 7.93 years (0.24) (see Table I).

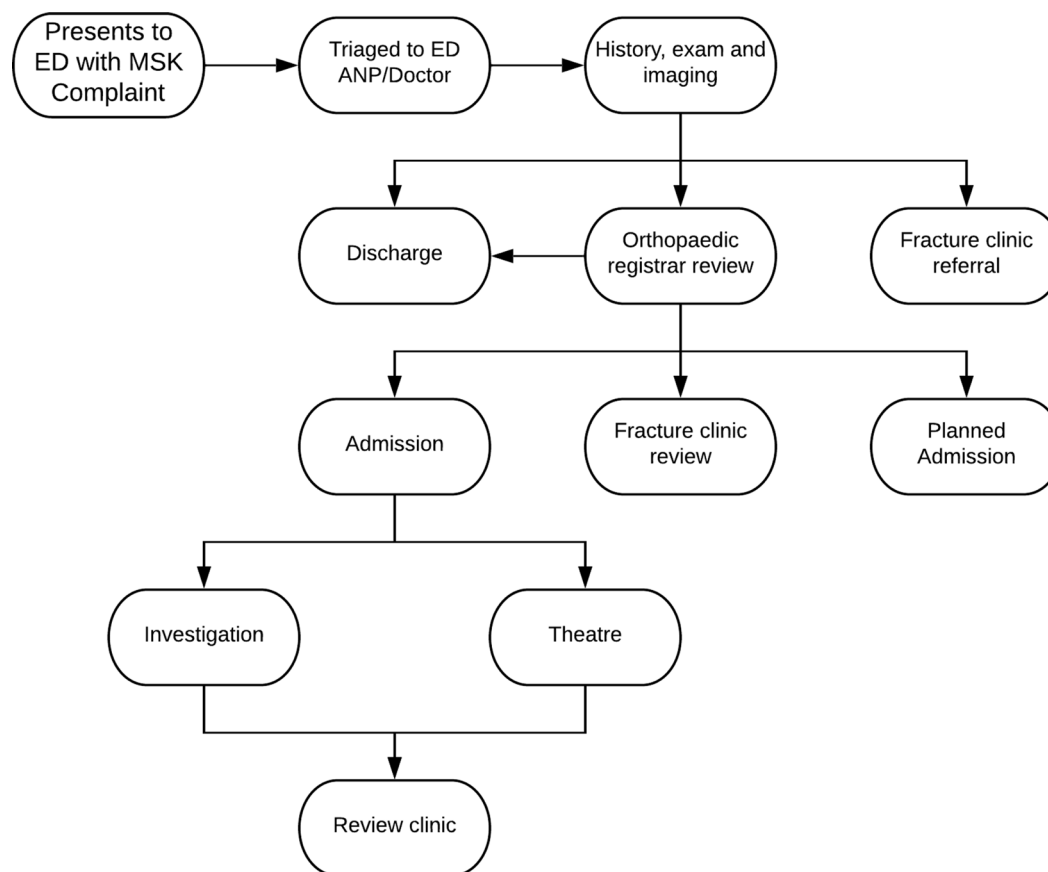


Fig. 1

Process map showing traditional orthopaedic referral pathway.

A separate anonymised database, created using Excel (Microsoft, Washington, USA), was used to prospectively collate the demographic and specific information about each referral made, including date of birth, time of referral, time of response, fracture characteristics, and outcome for all referrals for the first five weeks of the programme (from 21 March 2020 to 26 April 2020). Statistical analysis was performed using SPSS v. 26.0 (IBM, Armonk, New York, USA). Independent-samples *t*-tests and one-way ANOVA with Tukey post-hoc corrections were performed. Averages are presented as mean and standard error (SE). All data were stored on a secure Health Service Executive (HSE) server.

An interrupted time series (ITS) analysis was used to evaluate the effectiveness of the virtual intervention. Data about clinic attendances were collected for the equivalent time period in 2019 (25 March 2019 to 27 April 2019) and after the implementation of the TOP. The benefit of ITS analysis is that observed changes can be attributed to the intervention itself rather than by a separate trend in data.²

Results

Referral Outcomes. In total, 29 (9.8%) patients were reviewed by the on-call orthopaedic team and admitted

directly from the emergency department, with all remaining patients returning home. A further 17 patients (5.8%) were given a date to return for a planned DOSA, 105 (35.6%) patients were given outpatient face-to-face fracture clinic appointments to ensure adequate healing, to monitor for growth disturbance or for removal of cast, seven patients (1.5%) were referred to a specialist clinic, and 137 (46.4%) were discharged with no need for orthopaedic follow-up (Table II).

Presence of fracture. Of the 295 referrals, 81 (27.5%) patients had no evidence of a fracture. A summary of the common types of fracture is shown in Table III. The presence of fracture by referral outcome is illustrated in Figure 3. Overall, 11 patients were admitted without the presence of a fracture. Nine of these patients were admitted as part of an infectious workup, one was admitted for investigation of a potential nonaccidental injury, and the remaining patient was a late presentation of Perthes' disease²⁴ admitted for MRI. One patient with no fracture returned for wound debridement, irrigation, and closure.

Manipulation under conscious sedation in the ED. Overall, 17 patients underwent manipulation under conscious sedation in the ED for the application of a moulded cast. One patient (5.9%) was admitted post-manipulation for

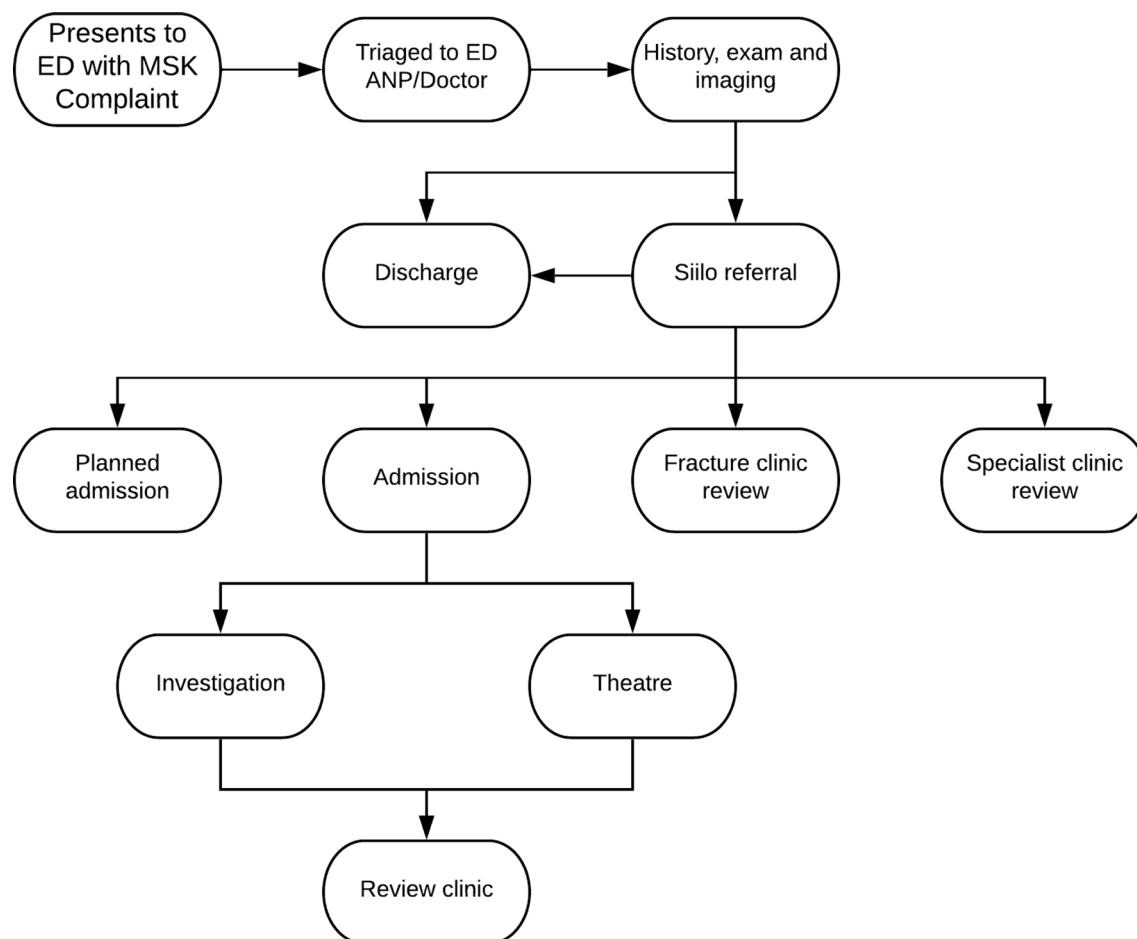


Fig. 2

Process map showing new referral pathway after implementation of the Trauma and Orthopaedic ePlatform (TOP). ANP, Advanced Nurse Practitioner; ED, emergency department; MSK, musculoskeletal.

Table I. Patient demographics

Demographics	Total
Female sex, n (%)	168 (56.95)
Mean age (SE)	7.93 (0.24)

SE, standard error.

Table II. Outcomes of referrals on day of surgery admission (DOSA).

Outcome	n (%)
Admitted	29 (9.8)
Fracture clinic	105 (35.6)
No orthopaedic follow-up	137 (46.4)
Planned DOSA	17 (5.8)
Referred to specialist clinic	7 (2.4)
Total	295 (100)

compartment review; the remaining patients were discharged from the ED to attend the fracture clinic. There was no return to theatre for further manipulation under anaesthesia of those discharged.

Table III. Summary of injury location as referred from the emergency department.

Site	Total, n	Fracture, n (%)	No fracture, n (%)
Upper Limb			
Clavicle	10	10 (100)	0 (0)
Humerus	9	7 (77.8)	2 (22.2)
Elbow	62	44 (71)	18 (29)
Both bone forearm	11	11 (100)	0 (0)
Distal radius/radii	46	42 (91.3)	4 (8.7)
Phalanx/metacarpal	9	9 (100)	0 (0)
Thumb (PP, DP)	11	11 (100)	0 (0)
Lower Limb			
Hip	13	0 (0)	13 (100)
Knee	14	0 (0)	14 (100)
Tibia	30	21 (70)	9 (30)
Ankle	27	19 (70.4)	8 (29.6)
Midfoot	22	13 (59.1)	9 (40.9)
Phalanx/metatarsal	12	10 (83.3)	2 (16.7)
Other	19	14 (73.7)	5 (26.3)

DP, distal palanx; PP, proximal phalanx.

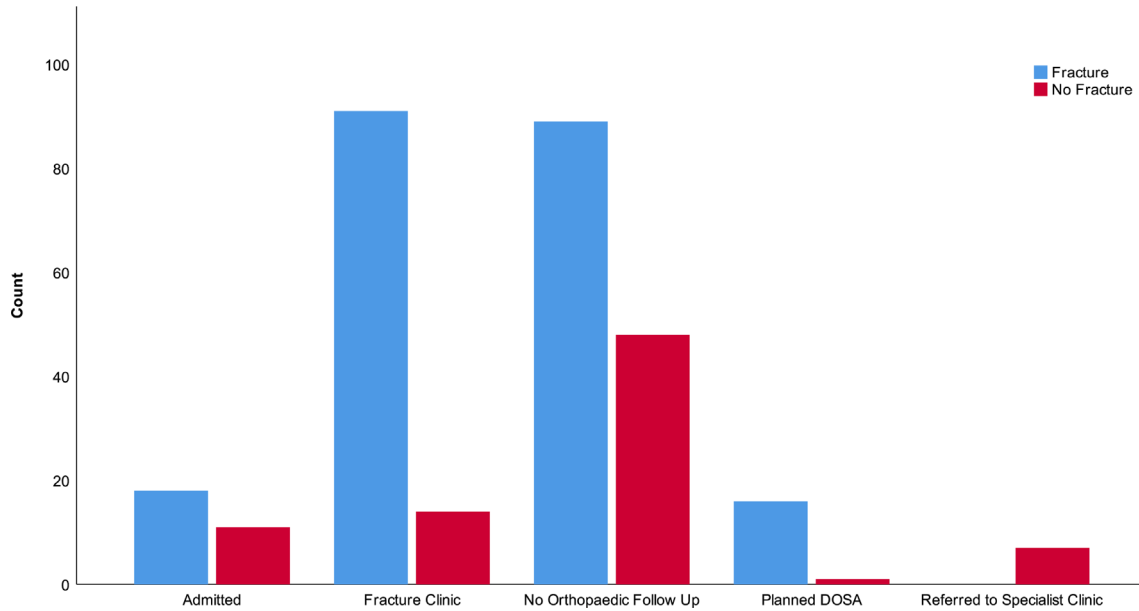


Fig. 3
Referral outcome by presence of fracture

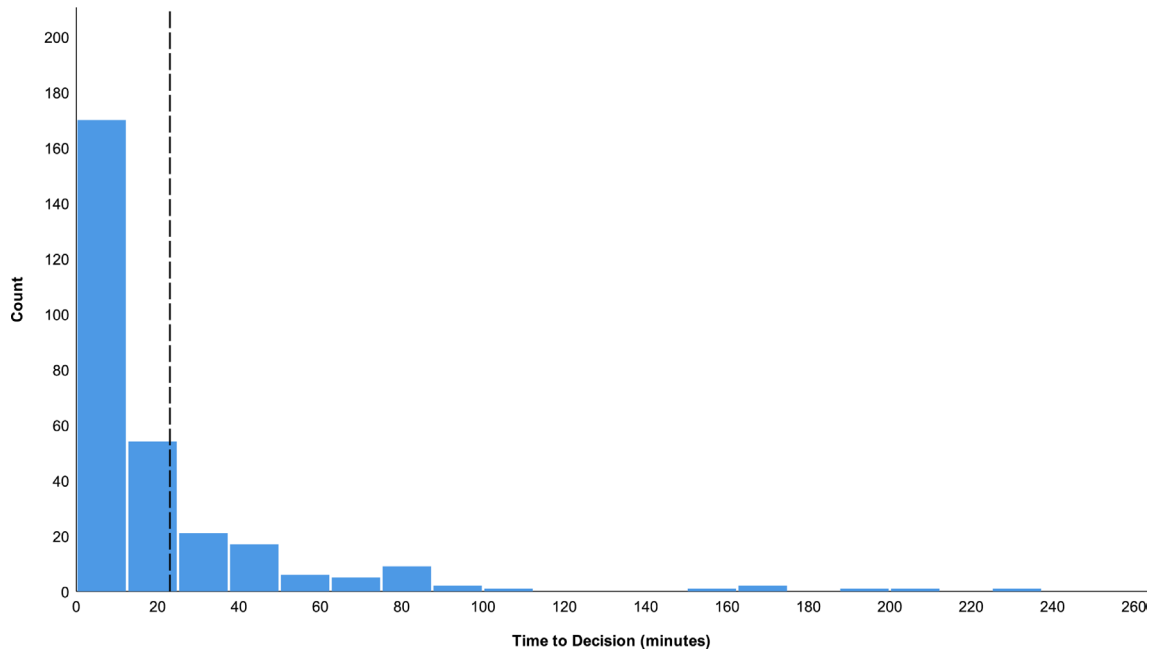


Fig. 4
Distribution of times to decision. The dashed black line represents 75% of patients referred.

Time to management decision. The mean time to decision was 20.14 minutes (SE 1.73). In total, 265 (89.8%) cases required no further information while 26 (8.8%) required a mean 4.08 messages (SE 0.49) to reach a decision. A statistically significant difference in the time to decision was noted between the two groups ($p = 0.013$,

independent-samples t -test). The average time for those requiring no further information and those requiring clarification were 17.56 minutes (SE 1.50) and 46.42 (SE 10.68), respectively. We note that our data is positively skewed (see Figure 4), and the median time to decision was 10 minutes (interquartile range (IQR) 8 to 23).

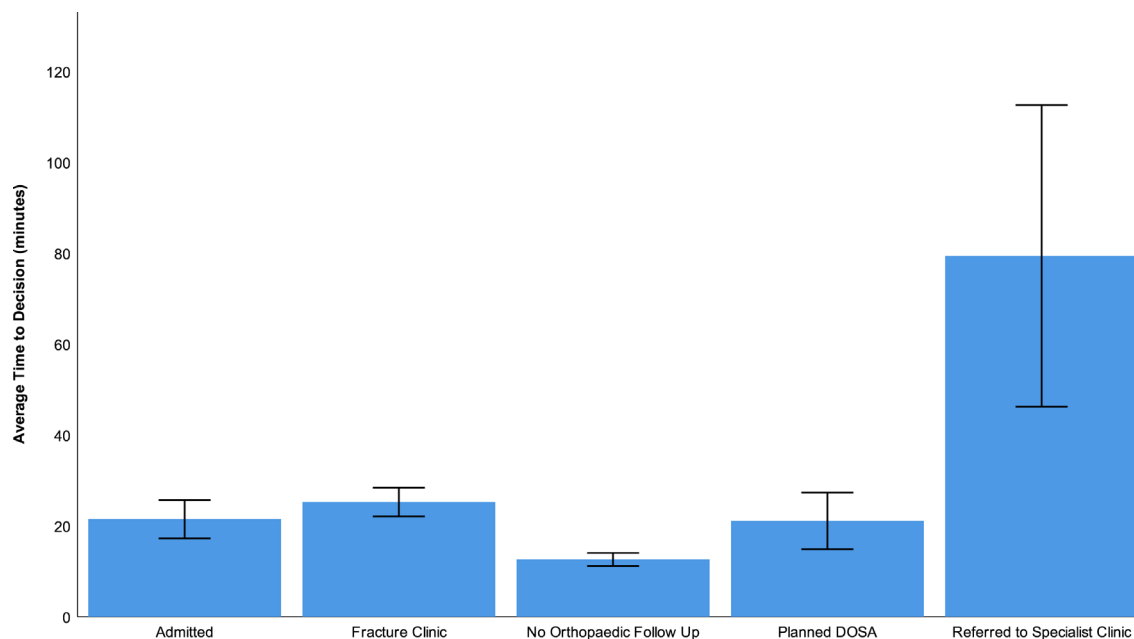


Fig. 5

Average time to decision by outcome (mean ± SEM)

Table IV. Time to decision by outcome.

Outcome	Time to decision, mins (SE)
Admitted	21.48 (4.20)
Fracture clinic	25.25 (3.18)
No orthopaedic follow-up	12.63 (1.42)
Planned DOSA	21.13 (6.22)
Referred to specialist clinic	79.42 (33.17)
Total	20.14 (1.73)

DOSA, day of surgery admission

Outlier data was assessed. On three occasions the on-call team were scrubbed and unavailable to answer via Siilo. On one occasion, a response time of 227 minutes was recorded; however, the on-call team had made reviewed the patient in ED but had not updated the Siilo case file.

Time to decision by outcome. The mean times to decision by outcome are shown in Figure 5 and listed in Table IV. There was a statistically significant difference noted between patients who were referred to specialist clinics and all other groups on one-way ANOVA ($p < 0.001$). A significant difference was also noted in time to decision between patients referred to the fracture clinic and those requiring no follow-up ($p < 0.005$).

Reattendance rates. Four patients reattended the emergency department after being discharged. Two were due to joint stiffness following at-home removal of a soft cast; one child had their soft cast removed in error by the parent, and one reattended after breaking their cast. No patients were readmitted, and none of the patients who reattended had their management altered.

Number of fracture clinic referrals. During the initial data collection period, a total of 105 patients were referred to the fracture clinic, seven referred to other specialist clinics, and 137 patients were discharged directly. Traditionally, all 249 of these patients would have been referred to the fracture clinic (“potential referrals”). During the equivalent period in 2019, 295 new referrals were made to the fracture clinic, and 44 emergency admissions occurred. There was no significant difference between the weekly number of referrals in 2019 and the potential referrals in 2020 (59.0 (SE 5.15) vs 49.8 (SE 6.86); $p = 0.315$, independent samples *t*-test). However, there was a statistically significant difference between the number of referrals in 2019 and the actual number of referrals (59 (SE 5.15) vs 21 (SE 2.17); $p < 0.001$, independent samples *t*-test) (Figure 6).

Discussion

The main findings of this study are that the TOP led to a significant discharge rate direct from the ED, a reduction in face-to-face clinic contact with definitive management decisions made in a timely fashion with financial and time savings for parents. To our knowledge, this is the first prospective analysis of an app-based trauma referral and orthopaedic management service in the literature.

The COVID-19 pandemic necessitated widespread adoption of social distancing protocols, something which is impossible in the typical orthopaedic outpatient setting. Since the first case in December 2019,²⁵ there has been an unprecedented strain on healthcare systems. The

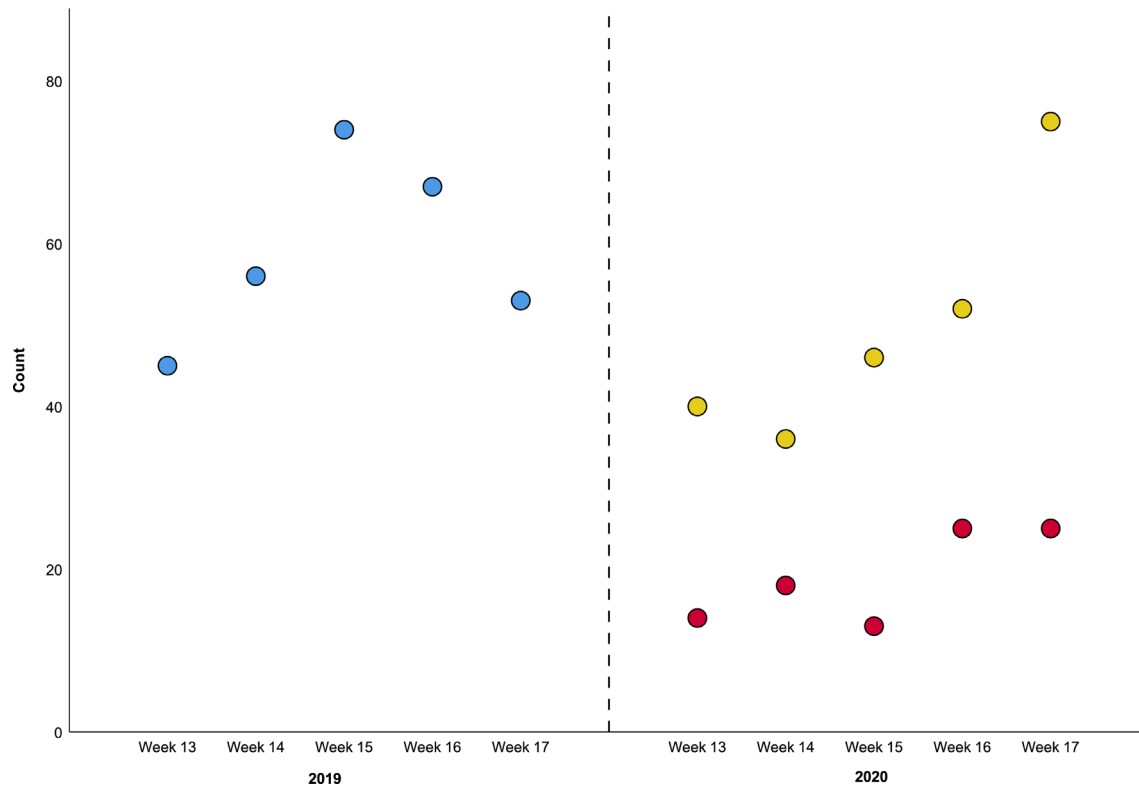


Fig. 6

Count of referrals for the equivalent period in 2019 and the reference period. Blue dots represent referrals to the fracture clinic in 2019; yellow dots represent potential referrals, and red dots the number of actual referrals in 2020

main aim of our redesign was to adapt to these new pressures without compromising on our standard of care with no extra resources. A usual redesign requires multiple stakeholders and the involvement of other allied health services. However, due to the pandemic and inability to recruit staff, this intervention used readily-available secure communication software which needed no formal training to use correctly. This allowed us to create an “off-the-shelf” solution which could be quickly adopted in other institutions to deliver a similar service.

Prior to the introduction of the TOP, referrals to the orthopaedic team were made through the hospital switchboard. This synchronous communication is cumbersome for the referring team. The switch operator may be engaged or the on-call orthopaedic surgeon scrubbed or engaged in direct patient care at the time. It is similarly frustrating for the orthopaedic surgeon when they miss the call as they are unable to ascertain who attempted to contact them and must wait for the referrer to try again. On receipt of the call, the receiver may have to move location to access relevant imaging. TOP allows for real time asynchronous communication using a standard format, including imaging, which can be responded to immediately, or once whatever task at hand is completed, by the on-call orthopaedic registrar

or consultant. Almost 90% of referrals required no further information. A contemporaneous electronic record is also generated on the app which is exported by the ED team and added to the patient’s record.

Traditionally at our institution, the ED would refer all fractures to the fracture clinic for definitive orthopaedic management. During the busy summer period, this can lead to significant strain on resources. Given COVID19 restrictions and the added public health effect of patients having multiple interactions with the hospital, use of public transport to attend clinics and the potential opportunities for spreading or contracting COVID-19, any reduction in risk is to be welcomed. While there may have been an increase in workload for the on-call orthopaedic team as every potential fracture referral was being discussed, there was a significant reduction in the number of face-to-face reviews. This frontloading was time efficient for patients with most having a decision within 10 minutes, obviating the need for return.

Of the 295 referrals made in the five weeks, 137 (46.4%) were discharged with a stable fracture or soft tissue injury management plan that required no formal follow-up, while still maintaining BOAST compliance.¹¹ As paediatric patients are accompanied by their parents, and often siblings, this represents a reduction in almost

300 people attending the outpatient department in the data collection period of five weeks.

Previous research has identified that up to 48% of all referrals to the fracture clinic do not have radiological evidence of a fracture.¹⁵ Our institution has previously published an audit into this, and it was found that up to 37% had no fracture and up to a quarter of referrals were unnecessary.¹⁴ However, while 27.5% of our referrals had no fracture on radiograph, 38.9% (n = 11) of our admissions also had no evidence of fracture but were admitted for septic arthritis or osteomyelitis treatment, or debridement or investigation of potential non-accidental injury. Similarly, patients with patellar dislocation and potential cruciate ligament injuries were referred to the fracture clinic using the TOP. This highlights how the fracture clinic sees more than just fractures.

Other institutions have shown that utilizing a VFC reduces the need for repeat radiographs,²⁶ and the extra time it afforded increased elective clinic work by 24%.⁷ Given the current reduction in capacity for all outpatient activity due to social distancing, we believe that every effort should be made to reduce unnecessary reviews. The fracture and specialist orthopaedic clinics run concurrently at our institution with a shared waiting room and typically have upwards of 90 patients attending within a five hour clinic window. With the reduction in waiting area space for patients and parents, it is not feasible to run an elective orthopaedic clinic service given the traditional fracture clinic workload and maintain social distancing.

Despite the reduction in the need for face to face reviews, there were no reported adverse events during the study. Four patients made an unexpected return to the ED, but this was not due to the new pathway. The timely instigation of a definitive management plan does not delay the majority of patients in the ED. Except for cases that required clarity on clinical examination or waiting for blood work, the average time to decision was 20 minutes. Half of patients had a decision within 10 minutes of being listed on the TOP and 75% within 23 minutes.

One limitation of our study is that it is reliant on having timely access to senior orthopaedic decision makers at all times. We are a paediatric tertiary referral centre with onsite orthopaedics, however we believe the readily customisable nature of the system is adaptable to other institutions.

The implementation of the TOP is achievable using readily available technology, without any additional resources, is novel and reduces the need for face-to-face review. Further evaluation of the impact of TOP on both patient and medical team satisfaction, along with an economic analysis, will be valuable.

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- T. Clarke: Maintained referrals database, Edited the manuscript.
- C. J. Green: Edited the manuscript.

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