

Original Research

Efficacy of a Photograph-Based Triage System Initiated During the COVID-19 Pandemic to Identify and Streamline Pediatric Foot and Ankle Referrals

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Abstract

Background: The COVID-19 pandemic required hospitals to reduce in-person visits. Although most pediatric foot and ankle conditions do not require urgent consultation, clubfoot (CF) relies on early identification and treatment. To avoid unnecessary hospital visits for infants, we developed a triage system using standardized clinical photographs of the child's feet taken by the parents for clinician review. This study assesses the efficacy of this triage system based on accuracy of the triage diagnosis (TDx) and time from referral to initial consultation (IC).

Methods: This is a retrospective cohort review of patients referred to a tertiary care pediatric institution for a foot and ankle condition from 03/16/20 to 09/15/20 (onset of COVID-19), and from the same period in 2019 (prior to use of the triage system). Patients were identified by referring diagnosis (RDx). Patients were excluded if they missed their initial visit or the RDx was not clear. Chart review was performed to collect demographic data, clinical photographs, RDx, TDx, IC diagnosis, and time to IC. Diagnosis accuracy (DA) scores were assigned: 0 when RDx or TDx did not match diagnosis at IC, 0.5 if the diagnosis was partly correct, and 1 when diagnoses aligned. Sensitivity and specificity of the photo-based triage system were calculated for patients referred for clubfoot.

Results: Of the 118 patients included, 62 were referred for CF and 56 for other foot and ankle conditions (FA). In 2020, 23/27 CF and 11/12 FA patients sent photographs. The average time to IC for FA patients was similar in both years (142 days in 2019 vs. 183 days in 2020, $p=0.24$), while the average time to IC for CF decreased from 66 days in 2019 to 31 days in 2020 ($p=0.08$). Accuracy for TDx in 2020 was high for CF (0.98) and FA (0.92) patients ($p=0.49$). Sensitivity and specificity of TDx for clubfoot patients were 100%.

Conclusion: Triage diagnosis was accurate and time from referral to consultation decreased for clubfoot patients from 2019 to 2020, supporting that this novel photo-based triage system for pediatric foot and ankle referrals is effective in identifying urgent consults and ensuring timely assessment.

Level of Evidence: III

Key Concepts

- Diagnosis of pediatric foot and ankle conditions by clinical photographs submitted by parents is accurate.
- Triage of pediatric foot and ankle referrals with submitted clinical photographs enables appropriate streamline of urgent consultations and avoids unnecessary visits for self-resolving conditions.
- Wait times for urgent consultations decreased with adoption of a photo-based triage system.

Introduction

In December of 2019, a rising number of cases of an extremely contagious acute respiratory syndrome were reported in China.^{1,2} By March 11, 2020, the World Health Organization declared COVID-19 a global pandemic.^{1,2} Most countries responded by urgent implementation of social distancing policies to prevent the spread of the virus.² As an increasing number of hospitalizations related to COVID-19 caused a significant burden on the healthcare system, hospitals and clinics began limiting in-person patient visits and shifting to virtual patient care.^{3,4}

As of March 16, 2020, our institution limited in-person visits to essential care only. Although many foot and ankle (FA) conditions are non-urgent and can safely wait for assessment, this is not true for clubfoot (CF) where early treatment in infancy is paramount.⁵ Treatment started between 28 days to 3 months of age has a higher success rate with a lower risk of relapse and surgical intervention as well as lower number of casts required and improved clinical outcome scores.⁵ Optimal triage of patient referrals is therefore critical to ensure an appropriate timeframe between referral and initial consultation.

Prior to the COVID-19 pandemic, children referred to our hospital with foot deformities were triaged for assessment

in either the Foot and Ankle or Clubfoot clinics based on the referring diagnosis in an electronic online referral form. All orthopaedic referrals were reviewed by a clinic nurse and assigned to the most appropriate provider. Any referrals for ruling out or managing clubfoot in an infant would be automatically scheduled for an in-person visit in the Clubfoot Clinic with one of two teams consisting of an advanced physiotherapy practitioner (APP) and an orthopaedic surgeon. Children suspected to have any other foot and ankle condition, such as metatarsus adductus, calcaneovalgus, congenital vertical talus, flatfoot or cavus foot, were scheduled for in-person assessment within weeks to months depending on the diagnosis and surgeon’s assessment of the information in the referral. Anecdotally, providers noticed that many of the patients initially referred for clubfoot, ultimately, had fewer concerning conditions, such as a positional deformity or metatarsus adductus, and did not need to be seen in the first weeks of infancy. During COVID-19, in order to minimize hospital visits to comply with pandemic regulations, the senior author developed a new triage system based on photos that were requested to the caregivers (Figure 1). Using these photographs, the senior author or their APP could make a preliminary triage diagnosis (TDx) and recommend a timeframe for initial consultation.

EMAILING PHOTOS FOR YOUR BABY'S FOOT ASSESSMENT IN THE ORTHOPAEDIC CLINIC

Your child has been referred to Orthopaedic Surgery at [REDACTED] because of concern regarding the shape of their foot/feet.

In order to help us obtain a preliminary diagnosis of your child's foot shape, and to safely and efficiently schedule your child's first appointment, we request that you send us photos of their feet.

Please see examples below.

Please email to [REDACTED] with your child's name, date of birth, and if available hospital record number, in the subject heading.

Instructions for Photos

1. From the top



2. From the front including the legs



3. From the inside



4. From the back



5. Of the soles (best to have the baby lying on their belly)



Figure 1. Referral instructions for photos of feet.

The goal of this study was to determine the accuracy of the assigned triage diagnosis based on photographs, compared to the confirmed diagnosis at the time of the initial consultation (IC) and to examine the time from referral receipt to scheduling of the first appointment. Time to initial consultation in 2020 was compared to the time for patients referred in the same period prior to the pandemic in 2019. We hypothesized that with the new triage system, TDx accuracy would be high and would enable reduction of non-urgent in-person visits while maintaining timely access to care for those patients with urgent conditions.

Materials and Methods

This was a research ethics board-approved retrospective comparative cohort study of patients referred to a tertiary care pediatric hospital for a foot and ankle condition before the COVID-19 pandemic between March 16 to September 15, 2019, and after the pandemic onset between March 16 to September 15, 2020, when a new photograph-based triage method was initiated. Patients were identified through Epic (electronic medical record) reports filtering for date range, foot and ankle and clubfoot providers, date referral received, date of first appointment, and referring diagnosis. Chart review of the identified patients was performed to collect patient age, gender, referring diagnosis, triage diagnosis (2020 cohort only), postal code, date of initial consultation and final diagnosis (virtual or in-person), and if photos were obtained prior to triage or consultation. The 2020 cohort's clinical photos and triage diagnoses were documented in an email to the scheduling clerks and scanned into the communications section of the patient's electronic medical record.

To ensure only patients requiring essential care were invited for in-person visits during the pandemic, the senior author developed a new triage system for foot and ankle referrals. When a referral was received, the parents were asked to email photos of the child's feet to the clinic as instructed in an information sheet emailed to them created by the clubfoot provider team (Figure 1). The photos were then directed to a foot and

ankle surgeon or APP to review (Figure 2). Using these photographs, the provider could make a preliminary triage diagnosis (TDx) and recommend a timeframe for initial consultation. If the photos were unclear or additional views were needed, the parents might be asked to submit additional photographs. If the APP had any doubt regarding the diagnosis, it was reviewed with the surgeon. When a clubfoot was identified or the diagnosis was unclear, these patients were booked for in-person assessment within a few weeks. For diagnoses with a high likelihood of spontaneous resolution (i.e., positional calcaneovalgus) or not requiring immediate treatment (i.e., metatarsus adductus, congenital vertical talus), the patients were either scheduled for a virtual, telephone appointment or in-person appointment at a later date. To ensure parents were not left anxiously waiting for appointments, electronic educational material was developed for all common foot and ankle diagnoses. These were distributed to the parents by email after the triage diagnosis was made with instructions on any relevant stretching exercises and information on their child's condition to provide reassurance.

Inclusion criteria were a referral to the Orthopaedic Department via the electronic referral system or via fax, a referring diagnosis of a pediatric foot or ankle condition, referral acceptance, and a recorded referral date and initial date of consultation. Patients were excluded if the initial consultation was not attended or if the referring diagnosis was unclear.

Patient data was analyzed in two cohorts with two subgroups: clubfoot patients seen in 2019 and 2020, and children with other foot and ankle diagnoses seen in 2019 and 2020. For the 2019 cohort, Diagnosis Accuracy (DA) scores were assigned to each referral by comparing the referring diagnosis (RDx) to the initial visit diagnosis. For the 2020 cohort, RDx and Triage Diagnosis (TDx) accuracy scores were assigned, where the RDx DA compared the referring diagnosis to the IC diagnosis and TDx DA compared the triage diagnosis to the initial consultation diagnosis. Scores were rated at 0, 0.5, and 1 where a score of 0 meant the two diagnoses differed, 0.5 if



Figure 2. Clinical photographs of a child with a left clubfoot submitted for triage.

the diagnosis was partly correct, and a score of 1 when the diagnoses were concordant. To determine the time between receipt of referral to the initial consultation, the date of receipt of the referral in the electronic health record was compared to the date of the first consultation appointment.

Patient characteristics and referral data were assessed and summarized using descriptive statistics. T-tests were performed to compare the following variables between cohorts and subgroups: time between referral and initial consultation (IC), age at referral, and diagnostic accuracy (DA) scores. A sub-analysis of patients who were referred under 1 year of age was performed to analyze the time to Initial Consultation for infants. Sensitivity and specificity of RDx and TDx were calculated for patients referred for clubfoot.

Results

Out of the 79 patients from March 16 to September 15, 2019, included in this study, 35 were referred for clubfoot

including nine patients over and 26 patients under 1 year old. One child older than 1 year presented for recurrence while none of the children under 1 year had relapse. Forty-four patients were referred for other foot and ankle diagnoses in the 2019 period. From March 16, 2020, to September 15, 2020, 39 patients were included in our analyses; 27 were referred for clubfoot and 12 for other foot and ankle diagnoses (Table 1). All clubfoot referrals in 2020 were under 1 year of age, including 1 recurrent clubfoot.

Of the 2020 cohort, 85% (23/27) of CF and 85% (11/13) of FA patients sent photographs for review. Time to IC for FA patients was similar in both years (142 vs. 183 days, $p=0.24$), while there was a non-statistically significant decrease in time to IC for CF patients in 2020 (66 vs. 31 days, $p=0.08$). However, CF patients had a shorter time to IC than FA patients in 2019 ($p=0.0005$) and in 2020 ($p=0.0001$). Referring DA score for CF improved from 0.74 in 2019 to 0.93 in 2020 ($p=0.05$).

Table 1. Cohort Demographic Characteristics, Accuracy Scores, and Time to Consultation

Patient Cohort						
	Clubfoot			Other Foot and Ankle Diagnoses		
	2019	2020	p-value	2019	2020	p-value
Cohort Size	35	27	--	44	12	--
Number of Infants (age <1 year)	26	27	--	5	6	--
Male Sex (N (%))	22 (63%)	17 (63%)	--	25 (57%)	4 (33%)	--
Distance from Institution (Km, (SD))	44.08 (64.69)	40.28 (36.59)	0.79	62.11 (143.78)	66.38 (153.98)	0.93
Mean Age at Referral (Months, (SD))	26.04 (51.0)	1.0 (2.4)	0.01	93.1 (60)	60.8 (79.7)	0.01
Mean Time to Initial Consultation (Days, (SD))	65.6 (98.0)	31.4 (19.16)	0.08	142.2 (87.85)	183.0 (157.1)	0.08
Infant Mean Time to Initial Consultation (Days, (SD))	54.2 (78.8)	31.4 (19.16)	0.15	127.8 (79.50)	183.00 (157.1)	0.15
Mean Referring Diagnosis Accuracy (%), (SD))	0.74 (0.4)	0.93 (0.2)	0.05	0.80 (0.4)	0.71 (0.5)	0.50
Mean Triage Diagnosis Accuracy (SD)		0.98 (0.23)			0.92 (0.29)	

SD, Standard Deviation; N, cohort size; Km, kilometer; Bold values represent statistically significant differences.

DA score for RDx in FA did not change significantly from 0.8 in 2019 to 0.71 in 2020 ($p=0.50$). The accuracy of TDx DA was high for both CF (0.98) and FA (0.92) patients ($p=0.5$) in 2020 with the new system. Additionally, CF patients were significantly younger than FA patients in 2019 ($p=0.0001$) and in 2020 ($p=0.0003$). In 2019, RDx sensitivity was 74% and improved to 96% in 2020. We did not calculate specificity, as referring doctors who did not think the deformity was clubfoot would have referred to our hospital specifying the alternate diagnosis. In 2020, sensitivity and specificity for TDx were both 100%.

When a referring diagnosis for clubfoot was inaccurate (0), they were most commonly self-resolving conditions mistaken as a clubfoot (Table 2). No patients had a TDx DA of 0, and only one patient had a TDx DA of 0.5. Table 2 lists the CF referring diagnoses with scores of 0 or 0.5 (incorrect or partly correct) and the one triage diagnosis that was partly correct. The photograph-based assessment for this latter patient suggested a clubfoot, but in the end, it was a flexible clubfoot-like deformity that at initial consultation was deemed either a severe positional deformity or a neurologic equinovarus. In the FA cohort, most often the patients with an RDx DA of 0 were referred for a non-specific description of

a deformity or for generalized pain in the foot or ankle (Table 3). Of these, three were ultimately diagnosed as flexible pes planus, two cavovarus feet, one clubfoot, one coalition, and three mild gait abnormalities. There was a single triage DA score of 0 in this group and no score of 0.5.

Discussion

To our knowledge, this is the first study to investigate the accuracy of a photo-based triage system implemented in an orthopaedic clinic. We report high diagnostic accuracy and appropriate time from triage to consultation with appropriate prioritization of urgent consults.

Baghdadi et al. reviewed the current literature to give recommendations for the most urgent common pediatric orthopaedic conditions that should still be managed urgently during the COVID-19 pandemic. The authors strongly recommend early intervention and treatment of clubfoot as well as septic arthritis, developmental dysplasia of the hip, tumors, spine fractures, and limb deformity requiring correction. No other foot and ankle diagnoses were deemed urgent.⁶ King et al. reported on their approach to adopting a virtual model of care in orthopaedic surgery during the pandemic. To determine appropriateness for a virtual care visit, patients seeking

Table 2. Summary of Clubfoot Referrals with Inaccurate Referring or Triage Diagnoses (RDx or TDx = 0)

Year	Referral Diagnosis	Triage Diagnosis	Confirmed Diagnosis at Initial Consultation
2019	Hindfoot Valgus		Normal examination
2019	Clubfeet		Resolved calcaneovalgus feet
2019	Right Clubfoot		Bilateral positional foot deformities with mild flexible cavus and slight adductus
2019	Right Clubfoot		Normal examination
2019	Clubfeet		Partly flexible bilateral metatarsus adductus
2019	Clubfeet		Positional left clubfoot
2019	Right Clubfoot		Resolved right positional calcaneovalgus foot
2019	Clubfeet		Resolved positional calcaneovalgus
2019	Clubfeet		Normal examination
2020	Clubfeet	Left Clubfoot	Left positional clubfoot vs. neurologic equinovarus

Table 3. Summary of Foot and Ankle Referrals with Inaccurate Referring Diagnoses or Triage Diagnosis (RDx or TDx = 0)

Year	Referral Diagnosis	Triage Diagnosis	Initial Consultation Diagnosis
2019	Ankle pain		Bilateral cavovarus feet
2019	Metatarsus adductus Intoeing		Bilateral intoeing with physiologically slightly marginal bilateral internal tibial torsion and femoral anteversion
2019	Bilateral congenital toe abnormalities		Lateral left foot pain that seems to be related either to peroneal tendinitis and or a fibrous or cartilaginous calcaneal navicular coalition
2019	Bilateral foot pain		Bilateral flexible pes planus and accessory naviculars
2019	Left lower leg weakness, severe hyper pronation, leg discrepancy, weakness of dorsiflexion, including the common extensors and anterior		Mild flexible asymptomatic left flatfoot with mildly tight gastrocnemius tendon
2019	Gross motor coordination problems. Bilateral metatarsus adductus bilateral pes cavus		Coordination issues, overriding 4th toe
2019	Pain and toe walking, pes planus and hammer toe		CMT type 1A and mild cavus foot deformities
2019	Left foot deformity and significant aversion when walking		Bilateral flexible flatfeet with tight Achilles tendons
2019	Bilateral equinovalgus foot		Clubfeet
2020	Delay in walking. Out-turning of left leg for sure at knee and foot. Bilateral flat feet.	Flatfeet	Minimal walking asymmetry

assessment were asked to complete an acuity and severity questionnaire. Patients were triaged based on their response to either an expedited, urgent, on-demand visit, or hand-off to the emergency department or direct surgical admission.⁶ Cases considered to be acute (e.g., recent surgical history) were directed to a virtual musculoskeletal triage channel, where an online real-time interview was conducted to guide scheduling priority. Many centers incorporated triage systems during COVID-19, few included photos or reviewed the system's efficacy.⁶ Our evaluation of the photo-based triage system developed in our institution shows accurate diagnosis and time to consultation.

Aside from CF patients being significantly younger than FA patients in both years, we also noted that children referred for clubfoot were significantly younger in 2020 (0.96 months) than in 2019 (26 months) ($p=0.01$). The younger age at referral of clubfoot patients during the pandemic may be related to the restrictions on in-person medical care visits imposed by the government at the beginning of the pandemic. Many family and pediatric practices deferred seeing patients in person until pandemic restrictions were lifted. Only urgent cases, such as newborn assessments or children who were acutely ill, were being seen by their pediatricians. We suspect this led to an overall decrease in referral rates

to our hospital at the onset of the pandemic, thereby lowering the mean age of our referred patients in early 2020.

RDx DA for clubfoot referrals improved from 2019 (0.74) to 2020 (0.93) ($p=0.05$) and sensitivity of a RDx for clubfoot in 2020 was 96%. The reason for this finding is unclear, but it may be that during the pandemic, referring doctors understood only critical cases should be referred to specialists and opted to personally observe conditions such as positional deformities.

The time between referral and IC for FA patients was similar for both years (142 days in 2019, and 183 days in 2020) ($p=0.24$), which is not unexpected given few of these are urgent diagnoses. CF patients had a shorter time to IC than FA patients in 2019 ($p=0.0005$) and in 2020 ($p=0.0001$). This is consistent with clinical recommendations that CF patients should be prioritized to promptly initiate treatment. There was a decrease in time from referral until initial consultation for the CF cohort from 2019 (66 days) to 2020 (31 days) ($p=0.08$). We believe that our photo-based triage system enabled us to appropriately prioritize the clubfoot patients and safely delay children with non-urgent conditions, thereby opening more visits for urgent consultations and allowing them to be seen sooner.

Triage DA was high in both cohorts, 98% accurate for the CF cohort and 92% accurate for the other foot and ankle conditions cohort ($p=0.49$). Sensitivity and specificity were 100%, supporting the DA scores. This demonstrates that our triage diagnoses were aligned with the initial consult diagnosis. There were frequent discrepancies between the RDx and confirmed diagnosis, suggesting that by reviewing the referring diagnoses via photo-based triage, we can avoid unnecessary visits due to errors in referring diagnoses and prioritize the patients most in need.

One of the limitations of our study is our small cohort, which limited our ability for performing subanalyses only of the clubfoot and other foot and ankle conditions. We could not analyze by diagnosis or age to better

understand the accuracy and referral to consultation times for other specific conditions, such as flatfoot, congenital vertical talus, or metatarsus adductus. Another limitation of this study is the lack of inclusion of parental and referring provider feedback of this system, which would be important in deciding if we continue triage with photos as they are the critical stakeholders in this process. Lastly, we did not create a standardized method for assessing the photos but relied on the triaging providers' clinical expertise for the assessment. Although we noted some variation in the positioning of the feet in the submitted photos, since parents provided multiple views, the images were sufficient to make a clinical diagnosis. In case of doubt, parents were either asked to submit additional photos or were scheduled in clinic for assessment virtually or in-person.

In conclusion, our study shows that a clinical photo-based triage system of pediatric foot and ankle referrals is accurate and can reduce wait times to initial consultation for urgent diagnoses.

When clinical resources are constrained or when in-person patient care is limited, the ability to remotely identify patients who need urgent care accurately is critical. This triage method is useful to comply with the COVID-19 restrictions implemented by many governments to decrease the spread of COVID-19 by eliminating unnecessary clinic visits. We continue to use this triage system and find it beneficial for streamlining our referrals and ensuring prompt access to care when indicated. Further studies should examine parent and referring doctor feedback about using these types of systems.

Additional Links

SickKids, AboutKidsHealth:

- Positional Clubfoot
- Treatment of Idiopathic Clubfoot
- Clubfoot: Treatment with a Boots and Bar Orthosis
- Metatarsus Adductus
- Positional Calcaneovalgus

Disclaimer

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