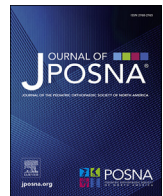




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Original Research

Care for Pediatric Patellofemoral Instability Prior to Orthopaedic Referral

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ABSTRACT

Background: Patellofemoral instability is a common condition in the pediatric population with increasing incidence. Recent guidelines recommend radiographs and nonoperative treatment for simple first-time dislocations and surgical consideration after a repeated event. However, it is not known whether non-orthopaedic clinicians are initiating these treatments. We sought to characterize injury history, diagnostic evaluations and treatments pursued by referring clinicians prior to orthopaedic evaluation of patellofemoral instability events.

Methods: We performed a retrospective review of pediatric patient records with a patellofemoral instability event referred for orthopaedic evaluation. Data collected include demographics, referral clinician specialty, previous injury, mechanism of injury, imaging performed and findings, treatments pursued, surgical timeline, and outcomes. Cases were grouped by their referring clinician specialty into emergency settings, primary care, and other settings.

Results: Of the 100 cases, 44 were referred from emergency settings, 41 from primary care, and 15 from other settings. Thirty-one cases ultimately underwent surgical intervention. The primary care group was the least likely to have performed radiographs prior to referral ($n = 21$, 51.2%) compared with the emergency group ($n = 43$, 97.7%). The primary care group was also found to be more likely to have already had recurrent dislocations ($n = 18$, 43.9%). Lastly, of the 32 recurrent cases, only 12 cases had been recommended physical therapy.

Conclusions: We found that radiographs and nonoperative treatments are inconsistently used prior to orthopaedic referral. This impacts the timeline of management, which can lead to further injury. Our study identified that there are upstream referral factors influencing patellofemoral instability outcomes. Future research may include methods to improve concordance with treatment guidelines.

Key Concepts:

- (1) Identifying clinician groups referring to orthopaedic practices for pediatric patellofemoral instability (PFI) events.
- (2) Describing evaluations and treatments pursued by clinicians for pediatric PFI events prior to orthopaedic referral.
- (3) Algorithm-based approaches are more adherent to current proposed pediatric PFI management guidelines.
- (4) Education of referring clinicians may help to improve surgical outcomes.

Level of Evidence: III, Retrospective Cohort Study

Introduction

Patellofemoral instability (PFI) is a common orthopaedic condition in the pediatric population with an estimated incidence of 23 to 43 per 100,000 person-years with the highest incidence in adolescents [1]. Recent studies suggest that the incidence of pediatric patellar dislocations requiring treatment has increased in recent years, which may be attributed to increased participation in youth sports [2]. Traumatic mechanisms are thought to be more common, with presentations ranging

from patellar subluxation–relocation to frank dislocation. Pediatricians and emergency department (ED) physicians typically serve as the first point of contact evaluating these injuries [3].

The anatomical risk factors contributing to PFI include elevated tibial tuberosity–trochlear groove (TT–TG) distance, patella alta, trochlear dysplasia, and patellar tilt, some of which can be determined from conventional radiographs. Additional risk factors include younger age, previous patellar dislocation, weakened vastus medialis obliquus, and conditions causing laxity of the medial patellofemoral ligament (MPFL)

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[4–6]. The recent consensus guidelines from Pediatric Research in Sports Medicine Society (PRISM) recommend obtaining radiographs and initiating nonoperative treatments such as physical therapy for the treatment of first-time dislocation [7]. Evaluation of whether there is concordance with current clinical practice has yet to be explored.

These guidelines also recommend consideration of surgical intervention with repeated subluxation after six months of nonoperative treatment or a second dislocation [7]. Studies have focused on recurrent PFI (rPFI) risk factors present on imaging in acute presentations, but few have explored PFI occurrences prior to orthopaedic evaluation [8], despite previous dislocation being the most significant risk factor for rPFI as well as increased risk of chondral injuries [6,9].

Most studies have focused on interventions and triaging performed in the ED or by specialists, such as orthopaedic surgeons and sports medicine practitioners [2,7]. In the US, nearly 35% of all covered individuals have public health insurance that typically requires referrals from primary care providers (PCPs) prior to seeing specialists (CPS-ASEC 2020; [10]); however, there is a lack of studies interrogating the PFI referral pathway from PCPs to specialists. Our purpose is to investigate diagnostic evaluations and treatments performed by referring clinicians and the number of prior dislocations and subluxations pediatric patients have before presenting to an orthopaedic practice.

Methods

This is a retrospective study involving the review of records pertaining to pediatric patients within a single hospital system over the last 10 years (January 2013–December 2023). Data were sourced using a Joint Data and Analytics Team inquiry of the electronic medical record and patients meeting the following inclusion criteria were reviewed: 10th revision of the International Classification of Diseases (ICD10) diagnosis code of PFI events (instability, subluxation, and dislocation of patella: S83.0-, M22.-, M23.5-), ≤ 18 years of age at the time of their first orthopaedic visit, and has had at least one orthopaedic follow-up visit.

A member of the research team performed clinical record review of samples meeting the above criteria; samples that were not seen by the hospital affiliated clinic were excluded. Data extracted from clinical record review included patient demographics, biometrics, referring clinician specialty, and laterality of the referral indication (“Referral laterality”). Additional record review focused on history taken during the initial orthopaedics consultation, which included prior subluxation or dislocation events of either side, laterality history (encoded as “bilateral” if there were previous contralateral PFI events reported), mode of impact (if any), treatment and imaging modalities performed prior to the orthopaedic clinic visit by referring clinicians and those recommended afterward by orthopaedic specialists. If the prior events were documented as “numerous” or “many”, they were encoded as >3 subluxations and/or dislocations. Post-referral contralateral PFI events were not utilized in the current analyses. The presence of a physical therapy referral was counted rather than determination of initiation of physical therapy by the patient as we were assessing attempted treatments by the clinician. Operative treatments were documented per patient, if a patient had subsequent operations for the contralateral knee (i.e. referred for left PFI but had subsequent right PFI surgical treatment), we only counted the initial operative treatment for the referred knee. Postoperative subluxations or dislocations were counted as PFI events and surgical revisions were also collected. We counted subsequent operations on the referred knee as surgical revisions, and postoperative PFI events of the referred and operated knee.

Statistical analyses were conducted using Statistical Package for the Social Sciences IBM SPSS Statistics for Windows, Version 29.0.2.0, IBM Corporation, 2023. Patients were stratified into the following referral group categories: emergency medicine/urgent care (“ED”, $n = 44$), primary care (“PCP”, $n = 41$), and self-referred or specialists (“Other”, $n = 15$). Further groupings included number of prior PFI events. Descriptive statistics were used to compare, calculate, describe, and

summarize data. To assess for possible associations between the referral pathway and previsit variables (number of PFI events, radiographs, treatments attempted), a Chi-square test of independence was conducted using SPSS. Variables reaching significance were then further assessed for effects on treatment outcomes. Possible confounding variables were then assessed using multiple linear regression analysis. Welch’s analysis of variance was conducted to determine whether time to surgical intervention after referral differed by prior imaging, prior physical therapy, or PFI events. The study was approved by the institutional review board.

Results

The cohort included 100 pediatric patients seen by orthopaedic specialists for PFI-related indications, of which 31 underwent surgical intervention. Of note, 97 of the cases were referred for unilateral evaluation, but were found to have had previous or concurrent contralateral events upon collection of history during initial orthopaedic evaluation, while the remaining 3 cases were referred specifically for bilateral PFI, therefore a total of 103 unstable knees were referred for evaluation. The study included 59 females and 41 males, with ages ranging from 5 to 18 years with a mean of 13.94 years ($SD \pm 2.7$ years). Additional demographics are shown in Table 1 and descriptive characteristics of evaluations and treatments attempted prior to orthopaedic referral are reported in Table 2.

Sex was not shown to influence operative outcomes (postoperative recurrence of PFI or surgical revisions) in this study ($P > .05$). A majority of PFI referrals are from emergency medicine physicians or pediatricians, with a significant difference noted in mechanisms of injury, with higher proportions of traumatic mechanism in emergent settings, $P = .041$, Fig. 1. While a difference was noted, it is seen that both mechanisms of injury are presenting to all referral contacts. It is also of note that there was a significant difference between mechanisms of injury and the number of prior PFI events at the time of referral, where atraumatic injuries were more likely to have had two or more prior PFI events, $P = .003$, Fig. 2. Multinomial logistic regression showed that younger age was significantly associated with presence of two or more prior PFI events ($P = .023$).

Table 1.
Participant demographics and injury classification.

Characteristic	Category	N (%) per patient	N (%) per knee
Sex	Female	59 (59%)	61 (59%)
	Male	41 (41%)	42 (41%)
Race	White	49 (49%)	50 (49%)
	Black	26 (26%)	26 (25%)
	Unknown	20 (20%)	22 (21%)
	Asian or Pacific Islander	4 (4%)	4 (4%)
	Native American	1 (1%)	1 (1%)
Referral laterality	Unilateral	97 (97%)	97 (94%)
	Bilateral	3 (3%)	6 (6%)
Laterality history	Unilateral	86 (86%)	86 (83%)
	Bilateral	14 (14%)	17 (17%)
Referral injury mechanism	Traumatic	43 (43%)	43 (42%)
	Atraumatic	57 (57%)	60 (58%)
BMI (per patient)	Mean	24.49	
	SD	6.6	
Age (per patient)	Mean	13.94	
	SD	2.7	

Table 2. Treatments and work-up prior to orthopaedic referral.

Prior treatments and events per patient		ED = 44 n (% within ED)	PCP = 41 ³ n (% within PCP)	Other = 15 n (% within other)
Imaging	None	1 (2.3%)	20 ² (48.8%)	3 (20%)
	X-ray	40 (90.9%)	13 (31.7%)	4 (26.7%)
	MRI	0 (0.0%)	1 (2.4%)	3 (20%)
	X-ray and MRI	3 (6.8%)	7 ¹ (17.1%)	5 (33.3%)
Previous ipsilateral dislocations	0	36 (81.8%)	13 (31.7%)	4 (26.7%)
	1	4 (9.1%)	10 (24.4%)	1 (6.7%)
	2–3	0 (0.0%)	5 (12.2%)	3 (20%)
	>3	4 (9.1%)	13 ³ (31.7%)	7 (46.7%)
Conservative treatments recommended	Immobilizer or bracing	40 (90.9%)	15 ¹ (36.6%)	9 (60%)
	Physical therapy	2 (4.5%)	8 ² (19.5%)	8 (53.3%)

Superscript numbers indicate the number of additional unstable knees from patients referred for bilateral evaluation. MRI, magnetic resonance imaging; ED, emergency department; PCP, primary care provider.

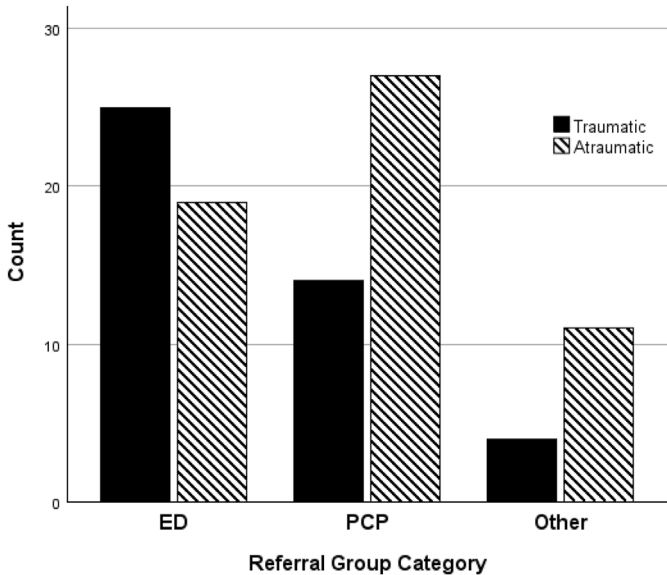


Figure 1. Traumatic vs. atraumatic PFI referrals. PFI, pediatric patellofemoral instability.

The PCP group had the least proportion of cases with imaging prior to referral (n = 21, 51.2%, $P < .001$; Table 2) and a higher proportion of multiple dislocations prior to referral (n = 18, 43.9%, $P < .001$). Two or more dislocations at the time of referral were significantly associated with undergoing operative treatment, $P = .017$. The three cases that were specifically referred for bilateral evaluation only underwent unilateral surgical treatment (Table 3). The mean time to surgical intervention is nearly doubled if there is no prior imaging, seen in Fig. 3. Additionally, 17 total cases were noted to have osteochondral fractures, 3 of which had not had imaging before referral (17.6% of fractures missed).

Interestingly, nonoperative treatments such as bracing or physical therapy were often not attempted prior to orthopaedic referral. While the cases referred from the ED typically were given a brace or immobilizer, most had not been recommended such treatments when referred from the PCP route (n = 26, 63.4%; Table 2). Of the 32 cases with two or more prior dislocations, only 12 had tried physical therapy prior to referral (Table 2).

Discussion

Patients with patellar instability can experience symptoms with any activity, which consequently limits their recreational activity levels and adversely affects their quality of life [11,12]. The occurrence of

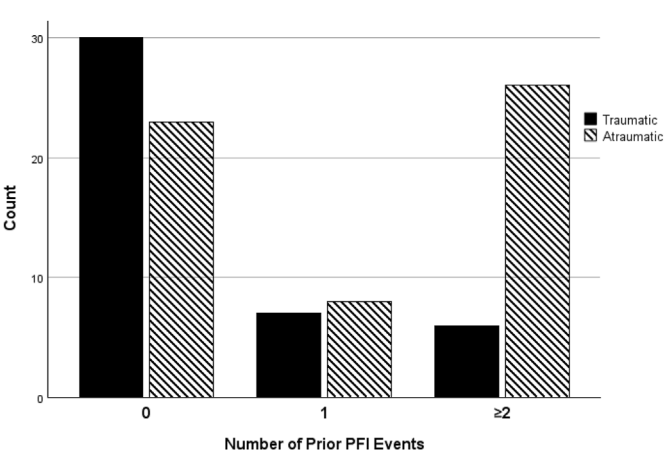


Figure 2. Mechanism of injury and prior PFI events. PFI, pediatric patellofemoral instability.

self-reductions after pediatric patellar dislocations could mask signs of injury that may delay care; however, this is an area lacking investigation. While recent consensus guidelines for treatment of first-time patellar dislocation recommend consideration of operative treatment after recurrent dislocation [7], it has not yet been determined what proportion of pediatric patients referred for orthopaedic evaluation fall into this category. Using the most recent guidelines, we sought to characterize the diagnostic evaluations and nonoperative treatments pursued by non-specialist referring clinicians prior to orthopaedic referral.

Our study found that among our cases, approximately one out of three of the referrals already had recurrent dislocations at the time of their first orthopaedic appointment, with the highest proportion from the PCP referral group. We found that 50% (n = 16) of the patients with repeated dislocation underwent surgical intervention that was significantly higher than those with one prior PFI event (26.7%) or no prior events (20.8%),

Table 3. Referred cases undergoing surgical intervention.

Surgical intervention	ED = 44 n (% within ED)	PCP = 41 ³ n (% within PCP)	Other = 15 n (% within other)
Yes	13 (29.5%)	12 (29.3%)	6 (40%)
No	31 (70.5%)	29 (70.7%)	9 (60%)

Superscript numbers indicate the number of additional unstable knees from patients referred for bilateral evaluation. All bilaterally referred knees had undergone unilateral surgical intervention at the time of study.

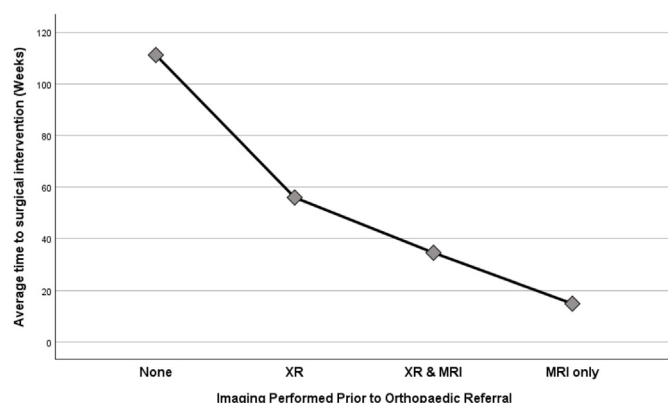


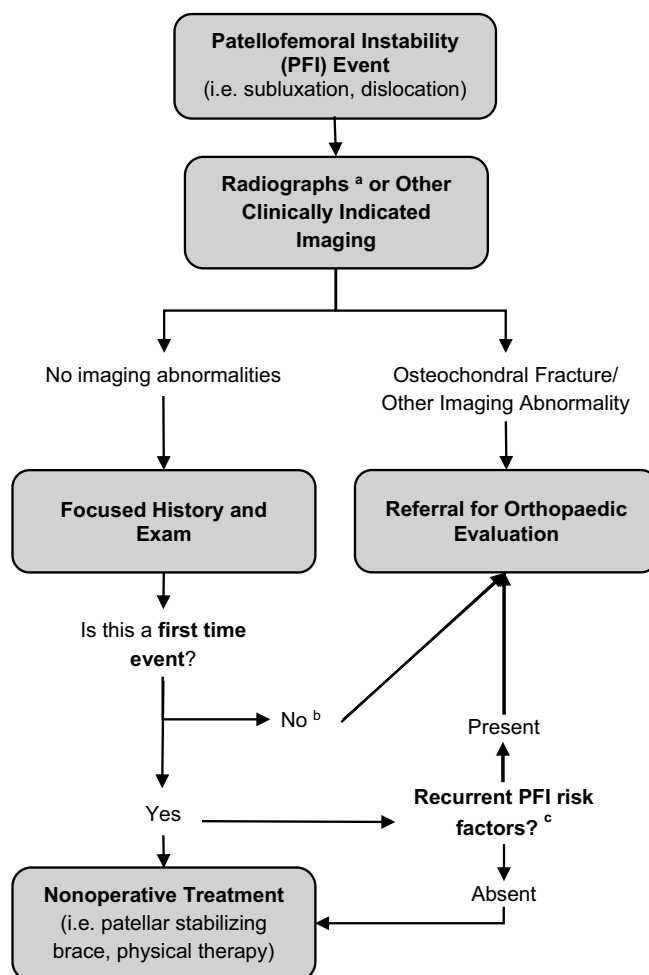
Figure 3. Prior imaging and time to surgical intervention.

$P = .017$, providing further evidence in support of the recommendation of surgical referral after a second frank dislocation [7]. Coupled with evidence that the increased number of dislocations can lead to worse outcomes [9], it suggests that physicians serving as the primary point of contact should assess for the number of previous PFI-related events to identify surgical candidates earlier.

Radiographs have been recommended as first line imaging for patellar instability events to triage urgent surgical cases, such as osteochondral fractures resulting in intra-articular loose bodies. We found that >90% of emergency department referrals had performed imaging, whereas referrals from non-emergent settings ranged from 26.7% to 31.7%. This has been demonstrated before in military populations [13]. Our study also found that 17.6% of fractures were missed prior to referral due to lack of imaging. This can lead to delayed care, in particular delaying time to surgical intervention that has been shown to result in poorer surgical outcomes [14]. Additional fractures were missed on initial radiograph views but seen on MRI. It is recommended to obtain anteroposterior, lateral, and axial views (such as Merchant or sunrise), which we did not assess but may be investigated in future studies. For example, the axial view is useful for assessing medial patellar avulsion fractures that could indicate MPFL injury, in addition to determining lateral patellofemoral tilt [15]. We also noted that prior MRI had the shortest time to surgical intervention, which may be due to several factors such as severity of injury. Further studies may investigate further whether referring clinicians should be considering advanced diagnostic imaging prior to orthopaedic referral.

We found that less than half of the cases had been referred to physical therapy prior to their referral. Physical therapy often takes several weeks before seeing noticeable changes and should be pursued prior to surgical consideration for most cases. Delaying the initiation of physical therapy can also lead to further dislocations during the trial period. It is possible that this may be improved upon by instilling an algorithmic approach for clinicians encountering PFI events in non-emergent settings (Fig. 4). In the emergent setting, there may be benefit from implementation of prompts linked to imaging orders for PFI, such as reminders to order axial radiographs. Clinicians in these settings may also benefit from promotion of continued education of these common pediatric musculoskeletal complaints.

A slightly higher percentage of female patients (59%) was found in our cohort (Table 1). It has been well recorded that females exhibit an increased incidence of generalized ligamentous laxity and anterior knee laxity compared with males in addition to higher likelihood of anatomical risk factors [5,16]. However, sex has not yet been found to influence patellofemoral kinematics [17]. With increasing female participation in sports, women are often considered to be at high risk for certain conditions like patellofemoral pain syndrome [18]. Previous studies found female sex to be associated with lower patient reported outcomes after MPFL reconstruction [19,20]. Another study including skeletally immature cases found no difference between the sexes in MPFL reconstruction



^a Radiographs should include anteroposterior, lateral, and axial views

^b Nonoperative treatment should be initiated concurrently with referral.

^c Recurrent PFI risk factors include history of contralateral events, anatomic anomalies (trochlear dysplasia, patella alta), and skeletal immaturity.

Figure 4. Proposed patellofemoral instability referral algorithm.

outcomes when adjusted for anatomical risk factors [21]. A review noted that there is limited and conflicting data on the impact of sex on PFI surgical outcomes [22]. In our cohort, sex was not shown to influence upstream referral characteristics (prior imaging or nonoperative treatments), whether surgical intervention was pursued, or operative outcomes; however, a power analysis was not performed, therefore there is risk of a type II error due to small sample size. Further examination of sex differences in approaches to PFI-related care in non-orthopaedic settings may be of use in future studies.

This study has several limitations. First, we only selected cases that were evaluated by orthopaedics within a single healthcare system, which may be biased based on insurance practice. It is possible that patients may present earlier to private orthopaedic practices if wait times are faster, or possibly even as primary points of contact. Additionally, cases successfully treated nonoperatively by non-orthopaedic specialists would have been missed as well. However, the data is still valuable and may apply to other academic institutions with similar patient demographics to ours. Additionally, because we did not select cases based on surgical interventions, the surgical sample size is small and unable to perform detailed analysis of outcomes. However, we did identify trends that can be explored further in larger cohorts. Lastly, there is variability among documentation by clinicians. This was mitigated by reviewing documentations leading up to the referral in addition to multiple follow-up

documentations afterward for consistency of reported PFI events and treatments. We did not include physical exam findings of PFI as research has shown there is weak inter-rater reliability among orthopaedic specialists [23]. While there is still clinical value in assessing the J-sign, Q-angle, and performing apprehension tests, the predictive value is minimal and should not be used to guide surgical management and should not preclude from pursuing conservative management [23].

Overall, we have determined that referring clinicians play a crucial role prior to orthopaedic evaluation of PFI. Our study described the various diagnostic studies and nonoperative treatments begun at the first point of contact and the number of PFI-related events occurring by the time of orthopaedic evaluation. Many study cohorts are limited to cases that underwent surgical intervention or were cared for by orthopaedic specialists [24]. However, we identified that these cohorts may be missing patients who are being receiving nonoperative care from their PCPs, therefore it is imperative that PCPs are also included as integral members of the treatment process. Future studies should evaluate whether algorithmic approaches in primary care improve concordance with treatment guidelines and barriers to implementation, as well as the effect of advanced diagnostic imaging on treatment outcomes.

Conclusion

Our study highlights critical contact points within the PFI diagnostic pathway that can be improved upon given the new consensus guidelines. Performing recommended imaging prior to evaluation by an orthopaedic surgeon and referral to physical therapy can help to streamline care, for example earlier identification of osteochondral fractures. Additionally, earlier referral may prevent adverse outcomes such as chondral lesions from repeated dislocations, increased risk of osteoarthritis, and reduced quality of life [9,25]. These findings suggest utilizing an interdisciplinary approach to improve pediatric PFI outcomes.

Author contributions

Emily Qian: Writing – review & editing, Writing – original draft, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ally A. Yang:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Halle Freiman:** Resources, Project administration. **Corinna Franklin:** Writing – review & editing, Supervision, Conceptualization.

Informed patient consent

The author(s) declare that no patient consent was necessary as no images or identifying information are included in the article.

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Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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