Pediatric Orthopedic Hoverboard Injuries: A Prospectively Enrolled Cohort

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Hoverboards pose a significant risk of musculoskeletal injury to pediatric riders. A prospectively enrolled cohort yielded 9 pediatric patients injured while riding hoverboards in 2016. Eight of the injuries involved the upper extremity, and one involved the lower extremity. No riders wore any safety equipment and injury patterns modeled those seen in skateboard riders. *(J Pediatr 2017;190:271-4).*

Self-balancing electric scooters, or "hoverboards," have become increasingly popular as modes of recreational transportation for children and adolescents since 2015 in the US.[1] These devices require a high level of balance, coordination, and strength, and if not properly operated by following the instructions in user manuals,[2] may lead to injury. With >2.5 million units sold in 2015,[3] injuries have been on the rise, requiring visits to urgent care centers, emergency departments, and clinical practices.

Orthopedic injuries due to other low-speed, nonmotorized, wheeled vehicles such as skateboards, in-line skates, bicycles, and scooters typically are low energy in nature, are prevalent in children and adolescents, and often occur in the upper extremity.[4-8] There has been a significant drive to improve the safety of these recreational activities with a focus targeted toward the education on proper riding and use of protective gear, including helmets and wrist guards, which may reduce injuries significantly.[9,10] These efforts have reduced dramatically the incidence of preventable injuries[11]; however, no formal intervention has been put into place for hoverboards. Valdez[12] recommended that providers give patients injured on hoverboards instructions for skateboard safety as a basic guide, input data on the patients into trauma registries, and advocate for legislative guidance to reduce the risk of injuries.

The purpose of this investigation was to determine the types of injuries associated with hoverboard use, the characteristics of injured riders, and whether safety equipment was used before injury in a pediatric population. In addition, given the similarities between hoverboards and other recreational devices such as skateboards, we sought to compare injury characteristics between the 2 devices. We hypothesized that the injury patterns and patient characteristics would be similar.

Methods

Approval for review of medical records with a waiver of informed consent for record review was granted by our hospital's institutional review board. From December 2015 through November 2016, patients who sustained an injury while riding a hoverboard requiring orthopedic surgery consultation and who presented to the emergency department in our Level 1 trauma-certified pediatric hospital located in a Northeastern metropolitan area were included in the study. These patients were identified by the research investigators the morning after their presentations, and were prospectively followed. Patients were excluded if they were >19 years of age.

The records of our included patients were then followed within our outpatient offices until completion of their care. Care was guided by injury and surgeon-patient discussion and not altered by inclusion in this study. At the completion of care, a review of the electronic medical records was performed by the authors. Demographic data including age, sex, weight, medical comorbidities, and developmental delays were included. Radiographs and physician progress notes were reviewed for injury characteristics including location and morphology, skin integrity, neurovascular status, and concomitant nonorthopedic injuries. Operative and nonoperative treatment modalities used in the emergency department, hospital, and outpatient offices were summarized. The use of safety equipment, including helmets, was noted if documented in the medical record from the emergency department or patients or families affirmed their use during office visits. Descriptive statistical analysis was performed to interpret the data.

Results

A total of 9 patients met the inclusion criteria for this study during the enrollment period (**Table**). The mean age was 11 years (range 6-15 years), and all patients were male. No patient had a medical or developmental history that would result in decreased bone density, coordination, strength, or intelligence. The use of helmets, wrist or shin guards, knee pads, or any other protective equipment was not noted for any patient.

The **Table** details each patient's injury and treatment. All injuries were considered closed fractures and no adverse events in the care of these patients was noted. Eight (88.9%) of the injuries involved the upper extremity, and one (11.1%) involved the lower extremity. Conscious sedation and closed reduction to improve the fracture alignment was required for 4 of the 9 (44.4%) upper extremity fractures (**Figure**). In addition, 1 patient sustained a closed distal fibula fracture, which was minimally displaced and casted in situ. All patients were

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Table. Patient and injury characteristics

Patient nos.	Patient age, y	Sex	Weight, kg	Medical comorbidities	Orthopedic injuries	Displacement of fracture	Treatment
1	8	Male	37.7	—	Distal radius fracture	+	CS, CR in ED
2	7	Male	21.0	—	Midshaft radius fracture	+	CS, CR in ED
3	14	Male	43.1	IgA deficiency	Distal-third radius and ulna shaft fractures	+	CS, CR in ED
4	13	Male	44.8	—	Salter-Harris 2 distal fibula fracture	–	Cast in-situ
5	11	Male	46.5	Asthma	Distal radius/ulnar styloid torus fracture	–	Cast in-situ
6	6	Male	18.1	—	Distal third radius and ulna shaft fractures	+	CS, CR in ED
7	12	Male	28.6	—	Distal radius fracture	–	Cast in situ
8	15	Male	—	Asthma	Distal radius fracture	+	Cast in situ
9	13	Male	—	Asthma, ADHD	Distal radius fracture	–	Cast in situ

ADHD, attention deficit-hyperactivity disorder; *CR*, closed reduction; *CS*, conscious sedation; *ED*, emergency department.

treated in their casts until fracture union as evidenced on radiography by bridging callus and a clinically nontender fracture site. At that point, the patients were progressed to full weight bearing and full use of their injured extremities. All fractures healed and all patients regained full pre-injury function.

Discussion

This analysis of orthopedic injuries sustained while using hoverboards illustrates the similarities between hoverboard injuries and skateboarding injuries in a pediatric population. A majority of skateboarding injuries are fractures to the upper extremities.[4] Injury to the upper extremity is likely attributable to an attempt to use the upper extremity to break a fall. Although wrist guards may prevent injuries to the wrist and forearm during skateboard use,[9] none of our patients had documentation stating the use of these protective devices, suggesting a targeted area for education. The use of safety equipment and proper riding techniques have been included by manufacturers in the devices' user manuals.[2] Diagrams about the ideal positioning and balancing on the device, information on the calibration of sensors, details on weight restrictions, and descriptions of the limitations of the device are all published in the manuals and included with the purchase of every hoverboard.

Our study also showed that children age 10-14 years are much more likely than others to be injured when using this motorized device, as 5 of 9 patients were in this age range. Again, this trend duplicates the injury characteristics seen in those who ride skateboards.[13] Children also have a higher center of gravity and may have underdeveloped body coordination skills, therefore increasing their risk of injury.[13] In addition, McKenzie et al[14] describe that male subjects account for 89% of skateboard injuries; a comparable rate to our all-male cohort. Finally, hoverboard user manuals almost uniformly recommend that the rider weighs between 20 and 100 kg (~44-225 lbs)[2,15,16]; however, we did have one patient who was outside of this weight limit.

Our cohort was small, so we were not able to draw epidemiologic conclusions similar to those that have been seen in large studies on skateboarding injuries. One such reason for the limited number of injuries may be the numerous press releases since late December 2015 by the US Consumer Product Safety Commission and local and national media sources about the fire-risk associated with operating hoverboards. Sales and usage of the devices may have decreased out of concerns for safety. Moreover, sales of hoverboards during 2015, the first true year of sales in the US, were estimated to be at approximately 2.5 million units,[3] and with likely geographic variability in purchasing, our region may not have seen high distribution and use. Finally, this study only included patients presenting to our region's Level 1 trauma-certified children's hospital. Although the pediatric emergency department has >55 000 visits per year and about 2000 orthopedic consultations are performed, our limited scope likely excluded a number of patients who sought treatment for injuries in urgent care centers, other hospitals, and outpatient clinics.

This study adds to the recently published literature on hoverboard injuries and specifically contributes to the discussion of orthopedic injuries and their treatment and the comparison of injuries to those sustained on skateboards. Siracuse et al used the National Electronic Injury Surveillance System database to look at the growing trend of injuries sustained on "scooters and skateboards (powered)" between 2011 and 2015.[17] Although this study also details an increase in forearm and wrist injuries (475%) and specifically wrist fractures (4000%) sustained on powered scooters and skateboards, there is no distinct code for hoverboards in the National Electronic Injury Surveillance System database and they do not discuss the treatment obtained by the patients. Schapiro et al[18] also described that a majority (74%) of the fractures seen in hoverboard riders were located in the upper extremities, a similar statistic to ours. They did find that one-half of their injured riders were female, a discrepant result to our all-male cohort. Finally, Donnally et al[19] showed that in their case series of 36 fractures sustained on hoverboards, 35 were located in the upper extremity. Their cohort had a greater incidence of fractures requiring operative intervention (11.1% vs 0% in our cohort) but a lower incidence of fractures requiring closed reduction (22.9% vs 44.4% in our cohort). From these 3 studies, as well as this investigation, we can conclude that pediatric hoverboard riders are at greater risk for sustaining fractures of the upper extremity than in other parts of the axial or appendicular skeleton.

The Consumer Product Safety Commission issued a statement noting concern about the burden of injuries sustained