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# A case series of pediatric seymour fractures related to hoverboards: Increasing trend with changing lifestyle



A.E. Kattan\*, F. AlShomer, A.K. Alhujayri, M. Alfowzan, K.A. Murrad, H. Alsajjan

Plastic and Reconstructive Surgery, Surgery Department, King Khalid University Hospital, King Saud University, College of Medicine, Saudi Arabia

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## ABSTRACT

**BACKGROUND:** Several recreational activities such as roller skating, skateboarding, and scooter riding create the risk for hand injuries, which are the fourth most commonly injured body part in relation to their use. Seymour first identified a specific pattern of digit injury as an open fracture affecting the distal phalangeal physis associated with nail avulsion from the eponychial fold. In this article, we report a series of Seymour fractures associated with misuse of the newly emerging recreational/transportation vehicle, the hoverboard.

**METHOD:** The study includes a retrospective chart review of patients who presented to a tertiary hospital between December 2015 and October 2016 with a Seymour fracture caused while operating a hoverboard.

**RESULTS:** A total of 13 patients were treated for Seymour fractures. The majority were male patients, and the group had a mean age of 10.3 years ( $\pm 2.21$ ). The affected digits were primarily the middle and ring fingers of the non-dominant hand. The injury mechanism reported by patients or families indicated that the child was operating the hoverboard in a sitting position with the hands grasping the wheel rim parts.

**CONCLUSION:** We report a case series of a fracture pattern resulting from the improper/unsafe use of a hoverboard. This type of fracture occurs with a tremendous load of energy. Although improper use was a factor, design fault also plays a role in causing the injury. Parent awareness and supervision are important to prevent such injuries.

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## 1. Introduction

In the pediatric population, the hand is a frequently injured body part. The prevalence of hand injury in this population is attributed to their curiosity, minimal motor coordination, and limited fear of pain, while adolescents tend to sustain hand injuries by participating in contact sports [1]. Hand injuries comprise 2.6% of hospitalized pediatric traumas [2], and 19% of all pediatric hand injuries consist of fractures [3]. As many as 20% to 30% of pediatric hand fractures involve the physis [4]. The Seymour fracture, which was first reported by Seymour in 1966 [5], represents a transverse extra-articular open fracture of the distal phalanges associated with nail bed injuries. The fracture includes Salter-Harris type I and II fractures as well as juxta-epiphyseal injuries [5–7].

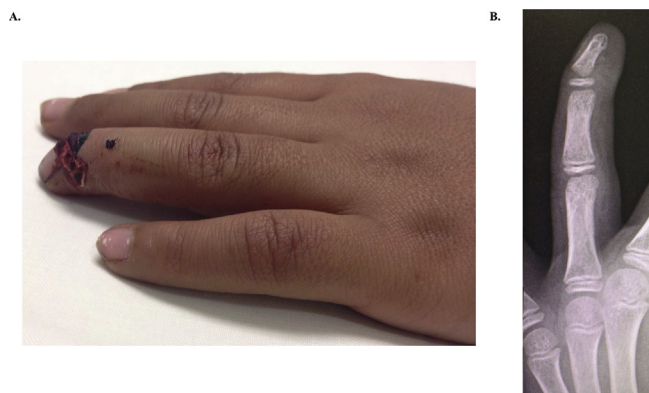
Hoverboards are self-balancing scooters designed for short-distance transportation and recreation, similar to skateboards. Sales of hoverboards are reported to have reached 2,578,000 units

purchased in the US alone [8]. The device comprises two wheels spanned by a flat surface where the user places his feet and that contains a lithium battery-powered motor. The user operates it by standing upright on the device and leaning forward or backward to propel the device. Some brands can reach speeds of 12 miles per hour [9,10]. Hoverboard users are regarded as vulnerable to falls and other dangers of the road and, together with pedestrians and bicyclists, account for approximately 50% of the total fatalities worldwide as reported by the World Health Organization (WHO) in 2013 [11]. The United States Consumer Product Safety Commission (CPSC) has received several injury reports related to the use of these vehicles due to fire ignition, smoke inhalation, falls, and collision, following which safety statements were issued recommending the use of padding and helmets, avoiding bystanders and traffic, and using the boards only over flat surfaces [12].

In this article, we present a case series of distal phalangeal fractures associated with nail avulsion (Seymour fracture) that occurred with the improper use of hoverboards. We discuss patient presentation, details of the associated mechanism of injury, and the overall management of these cases. This work has been reported in line with the SCARE criteria [13].

\* Corresponding author at: King Khalid University Hospital, Surgery Department 37, P. O. Box 7805, Riyadh 11472, Saudi Arabia.

E-mail addresses: [kattan@me.com](mailto:kattan@me.com) (A.E. Kattan), [Dr.fshomer@gmail.com](mailto:Dr.fshomer@gmail.com) (F. AlShomer), [Aziz.Alhujayri@gmail.com](mailto:Aziz.Alhujayri@gmail.com) (A.K. Alhujayri), [dr.muhammed@hotmail.com](mailto:dr.muhammed@hotmail.com) (M. Alfowzan), [Salid.murad@gmail.com](mailto:Salid.murad@gmail.com) (K.A. Murrad), [hfsajjan@hotmail.com](mailto:hfsajjan@hotmail.com) (H. Alsajjan).



**Fig. 1.** Clinical presentation of Seymour fracture. A. The clinical involvement of the left ring finger with open fracture of the distal phalanx together with nail avulsion. B. Radiographic image showing the radiologic findings with open juxta-epiphyseal fracture of the distal phalanx.

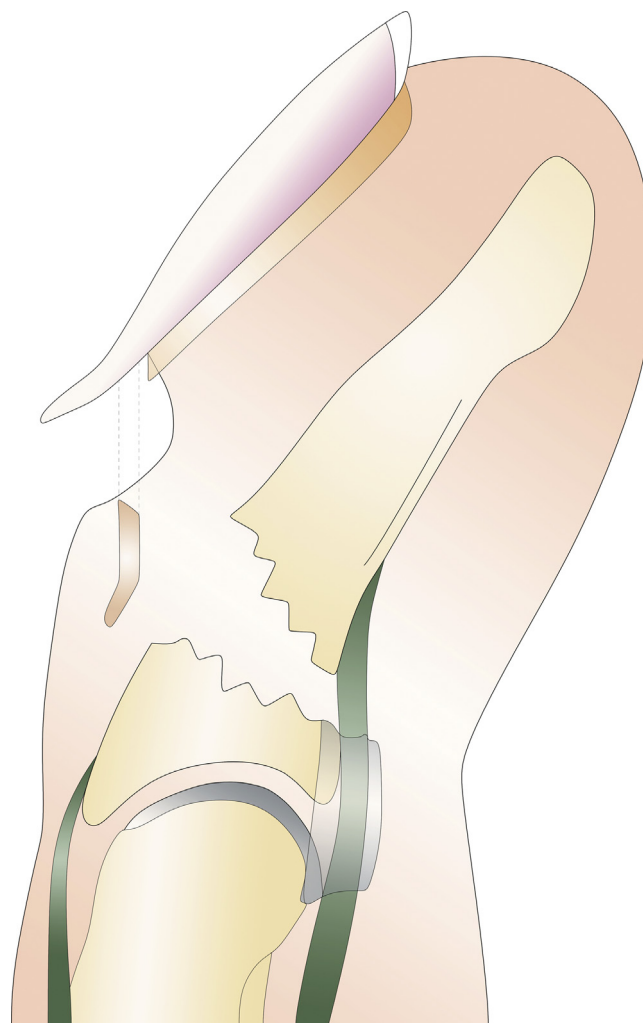
**2. Patients and methods**

A retrospective chart review was performed of all patients who presented with Seymour fracture that occurred while operating a hoverboard in a tertiary care academic hospital. The review period was December 2015 to October 2016. Demographic data including age, sex, hand dominance, digit involved, mechanism of injury, the line of fracture (Salter-Harris or juxta-epiphyseal), and initial and definitive management offered were documented. In addition, outcome/complications were recorded. Data were coded in Excel and analyzed with SPSS (version 22; 0.0.0). Results are presented as frequency distributions and mean values with standard deviation (SD). Consent was given by patients and parents/guardians for their data to be used for scientific publication. The work has been reported in line with the PROCESS criteria [14].

**3. Results**

We report on 13 cases of hoverboard-related injuries occurring between December 2015 and October 2016. The injuries were identified specifically as being open fractures of the distal phalanges with associated nail bed injuries, known as Seymour fracture (Figs. 1 and 2). Five of thirteen patients were found to have a juxta-epiphyseal type of injury, whereas the remaining patients had a Salter-Harris type of Seymour fracture. Affected patients were children aged between 6–12 years, with a mean age of 10.3 years (SD 2.21). All patients presented to the emergency department (ED), where initial wound management was initiated, followed by referral to a hand surgery service. On primary assessment, most of the patients received primary wound suture followed by admission to receive appropriate operative management. One patient was managed by emergency physicians with wound irrigation and primary suture approximations followed by hand surgery. The average time of presentation to the hospital was 1.61 days (SD 1.66), with a maximum of 7 days until definitive management was given. The most affected digit was the middle finger (six patients), followed by the ring finger (five patients), and the index finger (two patients). The left hand was affected in 61.5% of the injuries. The majority of the children (92.3%) were right-handed. The data are summarized in Table 1.

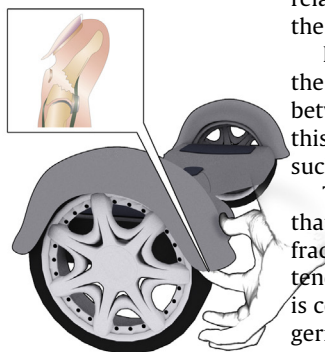
During the patient and family interview, all patients described a similar mechanism of injury in which the child was operating the vehicle in a sitting position with the hands grasping the wheel rim. The injured finger was impacted between the wheel and the wheel rim, as the child’s weight activated the propulsion of the wheels. The force applied from the wheel in direct contact with the



**Fig. 2.** Schematic illustration of Seymour fracture showing the lateral view with open avulsion fracture at the base of the distal phalanx and avulsion of the nailbed.

**Table 1**  
Demographics of patients with Seymour injuries.

Characteristics		No. (%)
Gender	Males	10 (76.9%)
	Females	3 (23.1%)
Age	6 years	1 (7.7%)
	7 years	2 (15.4%)
	10 years	2 (15.4%)
	11 years	2 (15.4%)
	12 years	6 (46.2%)
	Mean (SD)	10.3 years (SD 2.21)
Digit involved	Index finger	2 (15.4%)
	Middle finger	6 (46.2%)
	Ring finger	5 (38.5%)
Side involved	Right	5 (38.5%)
	Left	8 (61.5%)
Handedness	Right	12 (92.3%)
	Left	1 (7.7%)
Fracture Type	Salter-Harris	8 (61.5%)
	Juxta-epiphyseal	5 (38.5%)



**Fig. 3.** Schematic representation of the mechanism of injury. Improper operation of the hoverboard in which the child sits on the board while the hands are underneath holding the board. The child's weight propels the board forward, and the finger is impacted between the wheel and the wheel rim, inducing the digit injury.

impacted digit induced the injury. A schematic representation of the mechanism of injury is presented in Fig. 3.

All patients received operative management of nail disimpaction at the fracture site followed by wound irrigation and fracture reduction and nail bed repair with subsequent axial k-wire fixation.

On patient follow-up, none of the operated patients developed any pin-tract infection or osteomyelitis. After 4 weeks following operative fixation, the K-wire was removed, and range-of-motion exercises were started by the hand therapist. Patients received follow-up for a period of 6 weeks, and no complications were noted, with an acceptable range of motion of the distal interphalangeal joint.

#### 4. Discussion

Hoverboards are a new transport technology that has been introduced in recent years. Because of the number of injuries that have resulted from hoverboards, they should be used in the most controlled way possible to prevent any unnecessary injuries. Scooters, both motor powered and manually operated, have been linked to several forms of injuries, as reported by the United States CPSC. The report stated that 90% of scooter rider injuries involved children aged 14 years or younger. Moreover, children younger than 8 years of age represented one third of all scooter-related injuries [15]. The use of different recreation equipment such as roller skates, skateboards, and scooters among the pediatric population was investigated in relation to different injury patterns. It was shown that the forearm was the most injured body part, of which 191 fractures (8.1%) in 187 patients resulted from skateboarding, 65 fractures (2.7%) in 64 patients were due to roller skating, and 69 fractures (2.9%) in 66 patients resulted from scooter riding [16]. In comparison to non-powered scooters, powered scooters were shown to be associated with worse injuries, and injuries from non-powered scooters, with statistically significant increased risks to the hip, lower extremity, shoulder, and upper extremities among children between 2–12 years of age who were predominantly female [17]. Siracuse et al. reviewed all the injuries related to scooters, skateboards, and powered transport devices such as hoverboards over a period of 5 years. They found an increased percentage of fractures after the introduction of hoverboards to the market, with a tendency toward upper limb injuries, specifically the wrist and lower arm [18]. Donnally et al. reported a series of hoverboard-related fractures in December 2015. Of all the patients with fractures who presented to the ED, 36 cases (11.6%) were

related to hoverboards, with the majority of the cases involving the distal forearm [19].

In this report, a specific mechanism of injury was reported as the cause in most cases, and most of the involved patients were between 6 and 12 years of age and were males; this indicates that this group is at increased risk of associated injuries while operating such equipment.

The Seymour fracture is a specific form of digital injury pattern that involves transverse extra-articular Salter-Harris type I and II fractures of the distal phalanx distal to the insertion of the extensor tendon with associated nail-bed injuries [5]. This pattern of injury is considered an open fracture because the nail is avulsed and the germinal matrix is torn [1]. Al-Qattan et al. reported that this type of fracture has occurred both in adults as well as in children and adolescents. In addition, it was shown that most of these fractures in children have a juxta-epiphyseal nature that runs across the metaphysis at 1–2 mm distal to the growth plate [7]. In our population, five patients (38.5%) had a juxta-epiphyseal Seymour fracture, and the remaining patients had a Salter-Harris fracture pattern.

Different mechanisms of injuries were reported in the literature in which hyper-flexion of the distal phalanx by a heavy object hitting the digit (crush injury) or entrapment of the digit in a closing door lead to the injury. Clinically, the injured digit most often presented with a mallet-like deformity, with the middle finger being the most commonly involved [20].

Here, we report a similar form of injury in a pediatric population that results from the use of self-balanced battery-powered scooters. The mechanism of injury of injury, however, is similar: the child's weight on the hoverboard propels the device forward, and the fingers are trapped between the wheel parts. Hyper-flexion of the digit is caused by entrapment between the wheel and the wheel rim. The middle finger was the most involved digit, injured in 46.2% of reported patients; this finding was similar to previously reported fracture statistics [20].

Management of such fractures was reported to range from splinting to surgical intervention. Meticulous fracture reduction, repair of the nail bed, together with fixation of the distal phalanx in slight hyperextension were shown to improve the overall outcome [5,7].

Early detection and proper management are important for avoiding complications [4]. Complications reported in various studies include nail growth disturbances, growth disturbance of the bony distal phalanx, and a complete loss of distal interphalangeal joint flexion owing to an associated flexor digitorum profundus avulsion in zone 1, infection, necrosis of the fingertip, and malunion [21,22].

In this report, all our patients were treated promptly and provided with appropriate management following the standard of care in our institute for such injuries: disimpaction and repair of the nail bed, reduction of the fracture, and K-wire fixation across the distal interphalangeal joint. All patients were discharged with a volar slab and were prescribed an oral antibiotic for 1 week. The postoperative follow-up period was uneventful, and all patients recovered well with no significant deficits.

Our study is limited based on the fact that it was conducted in a single institute with a small population size ( $n = 13$ ). Moreover, all the cases reviewed were based on the ER physician's early recognition of this unique injury and proper referral to hand surgery for further management.

#### 5. Conclusion

With the introduction of new products such as self-balancing battery-powered scooters, public education plays a role in the safe use of these devices. In this article, we report a pattern seen in



patients with a fracture that requires a tremendous load of energy to cause and is due to the improper and unsafe use of hoverboards. Despite recommendations to wear protective gear such as a helmet and knee and elbow pads, and to ride the scooter over smooth surfaces away from traffic, a new injury pattern can happen, as reported here. Although improper use was a factor in the injuries, poor design of the hoverboard also plays a role in causing this injury. Parents are advised to properly inspect the scooter design for any sharp edges or levers that can cut or harm any body parts. Beside proper education of safety practices, parents are advised to supervise children while riding this equipment given that the power and speed of these machines make them much more than simple toys.

### Conflicts of interest

No conflict of interest.

### Sources of funding

No funding agent was implicated.

### Ethical approval

This study was approved by the Ethics Committee at the Medical College of King Saud University.

### Consent

Consent was taken from patients for their data to be used for scientific publication.

### Authors contribution

Dr. A. E. Kattan, was involved in the overall manuscript organization, drafting and proof-reading the manuscript.

Dr. F. AlShomer, was involved in data collection and statistical analysis and overall manuscript writing.

Dr. A. K. Alhujayri, was involved in manuscript writing and data collection and IRB application.

Dr. M. Alfowzan, was involved in the data collection and figures assembly.

Dr. K. A. Murad and Dr. H. Alsajjan were both involved in IRB application and follow up, figure drawing and data entry.

### Guarantor

All authors have agreed to the submitted version of the paper, and bear the responsibility for it.

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### References

- [1] R. Cornwall, E.T. Ricchetti, Pediatric phalanx fractures: unique challenges and pitfalls, *Clin. Orthop. Relat. Res.* 445 (2006) 146–156.
- [2] G.J. Galano, M.A. Vitale, M.W. Kessler, J.E. Hyman, M.G. Vitale, The most frequent traumatic orthopaedic injuries from a national pediatric inpatient population, *J. Pediatr. Orthoped.* 25 (1) (2005) 39–44.
- [3] M.S. Bhende, L.A. Dandrea, H.W. Davis, Hand injuries in children presenting to a pediatric emergency department, *Ann. Emerg. Med.* 22 (10) (1993) 1519–1523.
- [4] J.M. Abzug, S.H. Kozin, Seymour fractures, *J. Hand Surg. Am.* 38 (11) (2013) 2267–2270, quiz 70.
- [5] N. Seymour, Juxta-epiphyseal fracture of the terminal phalanx of the finger, *J. Bone Joint Surg. Br. Vol.* 48 (2) (1966) 347–349.
- [6] R.B. Salter, W.R. Harris, Injuries involving the epiphyseal plate, *J. Bone Joint Surg. Am.* 45 (3) (1963) 587–622.
- [7] M. Al-Qattan, Extra-articular transverse fractures of the base of the distal phalanx (Seymour's fracture) in children and adults, *J. Hand Surg. (Br. Eur. Vol.)* 26 (3) (2001) 201–206.
- [8] StatisticBrain, Hoverboard/Self-Balancing Scooter Industry Statistics, 2016, available on <http://www.statisticbrain.com/hoverboard-self-balancing-scooter-industry-statistics/>.
- [9] K. Boniface, M.P. McKay, R. Lucas, A. Shaffer, N. Sikka, Serious injuries related to the Segway® personal transporter: a case series, *Ann. Emerg. Med.* 57 (4) (2011) 370–374.
- [10] D. Roider, C. Busch, R. Spitaler, H. Hertz, Segway® related injuries in Vienna: report from the Lorenz Böhler Trauma Centre, *Eur. J. Trauma Emerg. Surg.* 42 (2) (2016) 203–205.
- [11] J. Xu, S. Shang, H. Qi, G. Yu, Y. Wang, P. Chen, Simulative investigation on head injuries of electric self-balancing scooter riders subject to ground impact, *Accid. Anal. Prev.* 89 (2016) 128–141.
- [12] T. Robinson, M. Agarwal, S. Chaudhary, B.E. Costello, H.K. Simon, Pediatric hoverboard injuries: a need for enhanced safety measures and public awareness, *Clin. Pediatr. (Phila.)* 55 (11) (2016) 1078–1080.
- [13] R.A. Agha, A.J. Fowler, A. Saeta, I. Barai, S. Rajmohan, D.P. Orgill, et al., The SCARE statement: consensus-based surgical case report guidelines, *Int. J. Surg.* 34 (2016) 180–186.
- [14] R.A. Agha, A.J. Fowler, S. Rajmohan, I. Barai, D.P. Orgill, Group P, Preferred reporting of case series in surgery; the PROCESS guidelines, *Int. J. Surg.* 36 (2016) 319–323.
- [15] P.A. Rhynders, R.M. Campbell, Scooters as a new trend in injury with opportunities for prevention, *J. Pediatr. Health Care* 15 (3) (2001) 155–157.
- [16] C. Zalavras, G. Nikolopoulou, D. Essin, N. Manjra, L.E. Zions, Pediatric fractures during skateboarding, roller skating, and scooter riding, *Am. J. Sports Med.* 33 (4) (2005) 568–573.
- [17] R. Griffin, C.T. Parks, L.W. Rue, G. McGwin, Comparison of severe injuries between powered and nonpowered scooters among children aged 2–12 in the United States, *Ambul. Pediatr.* 8 (6) (2008) 379–382.
- [18] B.L. Siracuse, J.A. Ippolito, P.D. Gibson, K.S. Beebe, Hoverboards: a new cause of pediatric morbidity, *Injury* 48 (6) (2017) 1110–1114.
- [19] C.J. Donnally III, C.M. Lawrie, A.J. Rush III, A.C. Baitner, The season of hoverboards: a case series of fractures, *Pediatr. Emerg. Care* 33 (5) (2017) 325–328.
- [20] M. Ganayem, G. Edelson, Base of distal phalanx fracture in children: a mallet finger mimic, *J. Pediatr. Orthoped.* 25 (4) (2005) 487–489.
- [21] I. Krusche-Mandl, J. Kottstorfer, G. Thalhammer, S. Aldrian, J. Erhart, P. Platzer, Seymour fractures: retrospective analysis and therapeutic considerations, *J. Hand Surg. Am.* 38 (2) (2013) 258–264.
- [22] B.A. Reyes, C.A. Ho, The high risk of infection with delayed treatment of open seymour fractures: Salter-Harris I/II or juxta-epiphyseal fractures of the distal phalanx with associated nailbed laceration, *J. Pediatr. Orthoped.* 37 (4) (2017) 247–253.

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