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ORIGINAL STUDY

Hoverboards and upper limb fractures in children

Stanley Jones, Sumukh Khandekar, Farhan Siraj, Balaji Talaseela, Mansur Ali Mohammed, Ahmed Kamhawy

From the department of Trauma and Orthopaedics, Al Ahli Hospital, Doha, Qatar.

***Purpose* : The purpose of this study is to report our experience of fractures in children riding Hoverboards.**

***Methods* : We undertook a prospective review of all children attending our hospital who sustained fractures whilst riding a Hoverboard. Data such as patient demographics, type of fracture sustained, treatment received, complications and outcome were collected.**

***Results* : Twelve children, 5 males and 7 females with ages ranging from 5.5 to 15.3 years were included in this study. All patients sustained upper limb fractures and the distal radius was the commonest fracture site (30%). Surgery was required in 6 (50%) out of the 12 patients because the respective fractures were displaced. No patient had any ongoing complaints or disability at the last clinic review.**

***Conclusion* : Children riding Hoverboards are predisposed to upper limb fractures and parents who purchase Hoverboards should be warned about this.**

INTRODUCTION

Two-wheeled, self-balancing battery powered personal transporters (PT) have become popular across the globe since they were first introduced (*8*).

The Segway, invented by Dean Karmen was the first to be introduced to the retail markets in 2001(*1*). It was introduced as a new and revolutionary vehicle and found use as a means of transport for sightseeing tours, police, military and emergency response personnel in urbanized areas (*4,5*).

The Hoverboard (also known as mini Segway, smart balance wheel or self-balancing board) has seen a dramatic increase in use since several such devices appeared on the market in China in 2014. It is mainly for personal use.

These personal transporters consists of two wheels arranged side by side attached to a small platform on which the rider stands. Specialized computer software and sensors keep the device upright when powered on with balancing enabled. The rider stands upright on the platform and leans forward to go forward or speed and returns to upright or leans slightly backward to slow down or stop. Unlike the Segway, the Hoverboard is hands free and controlled by the riders feet standing on the platform with built- in gyroscopic, sensored pads (*11*).

■ Stanley Jones (Consultant Orthopaedic Surgeon).
■ Sumukh Khandekar (Associate Consultant Orthopaedic Surgeon).
■ Farhan Siraj (Specialist Orthopaedic Surgeon).
■ Balaji Talaseela (Specialist Orthopaedic Surgeon).
■ Mansur Ali Mohammed (Specialist Orthopaedic Surgeon).
■ Ahmed Kamhawy (Specialist Orthopaedic Surgeon).
Department Of Trauma And Orthopaedics, Al Ahli Hospital, Doha, Qatar.
Correspondence : Stanley Jones FRCS (T&O), Department Of Trauma And Orthopaedics, Al Ahli Hospital, Doha, Qatar
E-mail: Jonesstan80@gmail.com

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Though deemed safe for use in urban pedestrian areas by the Centre for Electric Vehicle Experimentation in Quebec in 2006 (*6,14*) there have been a number of reports of serious injuries and fractures to Segway riders. The majority of these reports relate to adults (*2-4, 8,9,12*).

Though we are not aware of any reports in the published medical literature about fractures in children who were riding Hoverboards, there has been a reported death of a fifteen year old who was struck by a bus (*13*).

We have observed a surprising number of upper limb fractures in children who were riding Hoverboards and report our experience.

MATERIALS AND METHODS

After obtaining approval from our institutional review board we undertook a prospective review of all children who presented to the Accident and Emergency Department of Al-Ahli hospital in Qatar between October and December 2015 with fractures.

We (SK, BT, AK, MAM) developed a database that captured patient demographics, mechanism of injury, type of fracture sustained, treatment, complications and outcome.

During the study period 95 children were seen in the Accident and emergency department with fractures. Twenty fractures (21%) involved the upper limbs and seventy-five (79%) the lower limbs.

Criteria for inclusion into our study were children:

(1) aged less than 16 years.

(2) who sustained fractures related to riding the Hoverboard (Fig. 1)

(3) with fractures that were not pathological or re-fractures.

Twelve children met the inclusion criteria and were included in our study.

Once the diagnosis was made in the Accident and Emergency department the respective fractures were immobilized either with a plaster cast and/or an arm sling and those patients with displaced fractures requiring surgery were admitted to hospital the same day while those with un-displaced ones were discharged home with analgesia and advice to be reviewed in the Orthopaedic fracture clinic in 3 days.

All patients were reviewed in the Orthopedic Clinic at regular intervals where they were assessed clinically and radiologically.

Clinical evaluation included neurological assessment, limb deformity and range of movement of adjacent joints.

Radiological assessment included antero-posterior and lateral views of the affected limb or joint. All patients were seen at the last review by (BT and SK).

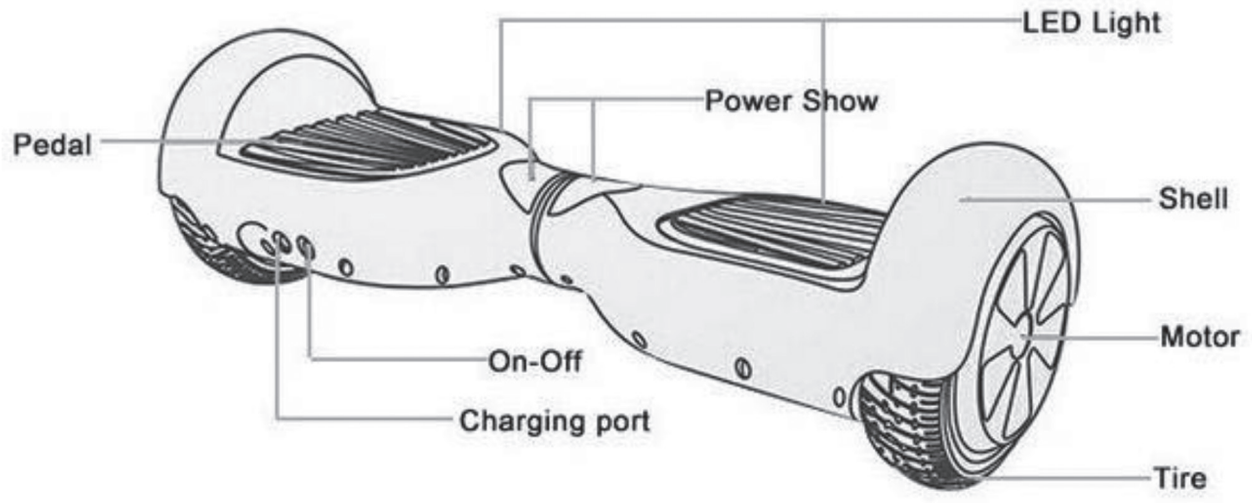

Fig.1. — Hoverboard

Table I. — Patient demographics of upper limb fractures due to Hoverboards

Patient	Age (years)	Gender	Side of injury	Weight (kg)	Fracture site	Treatment		Complications
						Non-operative	Operative	
1	5.5	F	R	18.5	Proximal humerus metaphysis	Arm sling		Nil
2	13	M	L	36.6	Proximal humerus metaphysis	Arm sling		Nil
3	12.3	F	R	52	Proximal humerus metaphysis	Arm sling		Nil
4	7	F	R	24	Distal humerus (supracondylar)	POP cast		Nil
5	6.2	F	L	20.1	Distal humerus (supracondylar)		Closed reduction, K wires and POP cast	Nil
6	13.3	M	L	84`	Displaced medial condyle humerus		ORIF and POP cast	Elbow stiffness resolved with physiotherapy
7	9.1	F	R	36.8	Radial head	Arm sling		Nil
8	11.5	F	L	43.5	Displaced Radius and ulna mid-diaphysis		ORIF and POP cast	Nil
9	8	F	L	34	Un-displaced distal radius	POP cast		Nil
10	9	M	L	32.9	Displaced distal radius		K wires and POP cast	Nil
11	15.3	M	L	60	Displaced distal radius		Closed reduction, K wires and POP Cast	Nil
12	12.4	M	L	57	Displaced distal radius		Closed reduction, K wires and POP Cast	Nil

M male, F female, L left, R right

Statistical analysis was undertaken using IBM SPSS Statistics 19 (IBM Inc. Armonk, New York, USA) Software. Descriptive statistics are reported as numbers (percentages) or mean (absolute range) as appropriate.

Parametric data were analysed using the student's t- tests and the significance level was set at a p value of less than 0.05.

RESULTS

Of the 12 children who qualified for inclusion in this study 5 (42%) were males and 7 (58%) were females. (Table I)

The mean age of the patients at the time of injury was 10.2 years (range 5.5 - 15.3) and the mean weight was 39.9 kg (range 18.5-84 kg). No patients wore helmets.

No patients had bilateral or open fractures and all the fractures involved bones of the upper limbs only. In addition none of the patients had associated injuries such as head or chest injuries.

The commonest fracture site was the distal radius (33% of patients). Three out of the four (75%) patients with distal radius fractures had displaced fractures (more than 50% displacement) that required surgery and this involved manipulation under anaesthesia and stabilization of the fractures using 2 percutaneous K-wires.

Surgery was required in 6 (50%) out of the 12 patients because the fractures were displaced. Of those who required surgery the hospital stay ranged from 1-2 days and no patient required admission to the intensive care unit. Older children required surgery but the relationship between age and the need for surgery was not statistically significant (p value

=0.2). Similarly heavier children required surgery but the relationship between weight of the children and the need for surgery was not statistically significant (p value =0.18). No patient has required further surgery.

We did not observe any post-operative complications such as neurological injury, infection, residual deformity or reflex sympathetic dystrophy

One patient with a displaced medial condyle fracture of the humerus developed elbow stiffness following surgery (open reduction and internal fixation) but this resolved with a course of physiotherapy and he had no complaints at his last review.

The follow up ranged from 6-9 months and at the last review no patient had any ongoing complaints or disability.

DISCUSSION

The Hoverboard and Segway personal transporters are powered by lithium ion batteries, achieve top speeds of up to 12.5 mph (20km) and on a fully charged battery depending on the terrain, riding style and condition of the batteries. The Hoverboard is capable of covering a maximum distance of 12 miles (19.4 km) while the Segway can cover a distance of 24 miles (38.6 km) *(7,10)*.

The desired speed is established and maintained by modulating the extent and duration of the rider's fore/aft weight shifts.

All previous reports in the medical literature on injuries and fractures suffered as a result of riding personal transporters have been on the Segway *(2-4,8,9,12)*. The median ages of the reported series were 38 years (range 14-80) and 50 years (range 16-80) respectively *(4,9)*. Only the report by Roider et al included a few children whose ages were greater than 14 years but they did not elaborate on these children and the injuries sustained *(9)*.

The median age of the children in our series was 9.1 years with a range of 5.5 -15.3 years and it is rather surprising that a child as young as 5.5 years rode a Hoverboard.

The majority of our patients were female (58%) and this compares with the report by Boniface et al on Segway injuries in adults with a female preponderance of 73% though the report by Roider et al affirms a male preponderance *(4,9)*.

A report by Mikkelsen et al confirmed that 2 patients sustained fractures while riding the Segway for the first time *(8)*. In our series 4 (33%) patients suffered fractures riding the Hoverboard for the first time. The other 8 patients had used the Hoverboard before and were conversant with its use.

All the fractures in the patients in our series involved only the upper limbs unlike reports on injuries related to the Segway that involved both the upper and lower limbs. This we believe is due to a number of factors :

- the patients fell off the Hoverboards onto their outstretched arms,
- the lower maximum speeds of the Hoverboard (6.2 mph in the version of Hoverboards used by our patients) compared to the Segway,
- patients claimed they were travelling at speeds lower than the maximum speed,
- there were no collisions with other vehicles,
- lower weight of our patients compared to adults (Segway series) hence lower momentum.

The left upper limb was the most commonly injured limb occurring in 8 out of the 12 children. This we believe is related to hand dominance.

Fifty percent of our patients required admission to hospital for surgery. This rate is high compared to the reported admission rates of 14% by Roider et al and 24% by Boniface et al on Segway related injuries *(4,9)*. We believe our rate is higher because these other reports included not only patients with fractures but also those with soft tissue injuries. In addition in those reports some patients were admitted to hospital for orthopaedic surgery a few days after the initial injury and hence were not included in the original analysis.

None of the patients in our series who required admission to hospital were admitted to the intensive care unit (ICU). This is at variance to other reports on Segway injuries where a number of patients required admission to the ICU because of associated injures such as head injuries *(4,12)*.

The mean length of hospital stay for the patients in our series who required surgery was 1 day (range 1-2 days). This compares favorably to the reports on Segway related injuries with mean length of hospital stays of 4 days (range 1-9 days) and 2.5 days (range 2-7 days) respectively *(4,9)*. We believe the

length of hospital stay in our patients were shorter because the patients were younger, the fractures involved the upper limbs only and there were no associated injuries.

None of our patients had post-operative complications such as infection or neurovascular injury, though one patient developed a stiff elbow after surgery for a displaced medial condyle fracture. This resolved after intensive physiotherapy and he had no limitation of elbow movement nor disability at the time of his last follow up.

None of the other patients had any disability or complaint at their last clinic review.

The limitations of this study are the patient numbers are small and this report does not include patients from other hospitals in Qatar thus underestimating the true incidence of Hoverboard related fractures.

Though the patient numbers are small we believe this is irrelevant as this is the first exclusive report of children who sustained fractures after riding a Hoverboard and highlights a number of important points. In addition 60% of all upper limb fractures treated in our hospital during the study period were the result of Hoverboard injuries.

In conclusion, children riding Hoverboards are predisposed to upper limb fractures and parents who purchase Hoverboards should be warned about this.

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