

## Traumatic Foot Amputation among Young Riders of All-Terrain Vehicles

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### ABSTRACT

**Background:** All-terrain vehicle (ATV) is an off road sport that gained its popularity in the recent 20 years in our community. Most of the existing vehicles' rides are in the desert. However, most of the ATVs are old and lack regular check-ups of its safety measures. Therefore, different hospitals that are located near to the desert have documented many foot amputations with other associated injury. The most common mechanism of injury is feet get trapped in the ATV chain and get crushed and amputated due to the lack of cover of the ATV's motor chain.

**Methods:** Our purpose of the study is to estimate and describe the traumatic feet amputations in children caused by ATVs riding. A retrospective chart review was conducted from December 2007 until January 2018 that included a review of the radiographs, patient demographics, type of injury, associated injuries, mechanism of injuries, hospital course and the outcome.

**Results:** The study identified 49 cases in the study period with a mean age of 3 years 9 months. All patients had an isolated right foot injury and partial/ complete amputation of one or more toes without any serious associated injuries.

**Conclusions:** There is an urgent need to educate the public toward the danger of this sport for children under the age of 14 years with establishing a strict regulation to limit these preventable injuries.

**Keywords:** Amputation, ATV, Children, Foot Injury, Trauma.

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### INTRODUCTION

All-terrain vehicle (ATV) also known as a four-wheeler is an off-road vehicle which consists of a seat that the driver straddle on, along with handgrip control and engine size ranging from 49 to 1000 cc.<sup>1</sup> ATVs are constructed in an unsafe manner, since they are designed with limited turning radius, small width tires with low-pressure, and high central mass.<sup>2</sup> However, drivers can go with high speed reaching to 120km/h or more. In recent years the recreational use of ATVs outside Riyadh city in the desert has increased especially in winter season. Saudi Standards Metrology and Quality Organization (SASO) has established new mandatory standards for ATV in 2014, yet nearly all these stations where drivers can rent ATVs don't have a single regulation prohibiting young children from riding the vehicles nor safety measures.<sup>3</sup> Safety of these vehicles has been a major issue due to a high number of traumatic foot amputation in children and it's becoming

a major concern to pediatric orthopedic surgeons in these regions.<sup>4</sup> Different international studies have showed the great risk of driving ATVs on children.<sup>4-7</sup> The purpose of this study to estimate and describe the traumatic foot amputations and associated injuries caused by riding the ATVs, and to study all significant factors related to the foot injuries that will increase the community's awareness and to improve the preventive regulations.

### METHODS

A retrospective chart review study was conducted from December 2007 until January 2018, including the date from previous case series study from December 2007 until November 2009 that was published by the senior author.<sup>4</sup> An IRB approval was obtained from King Abdullah International Medical Research Center. The

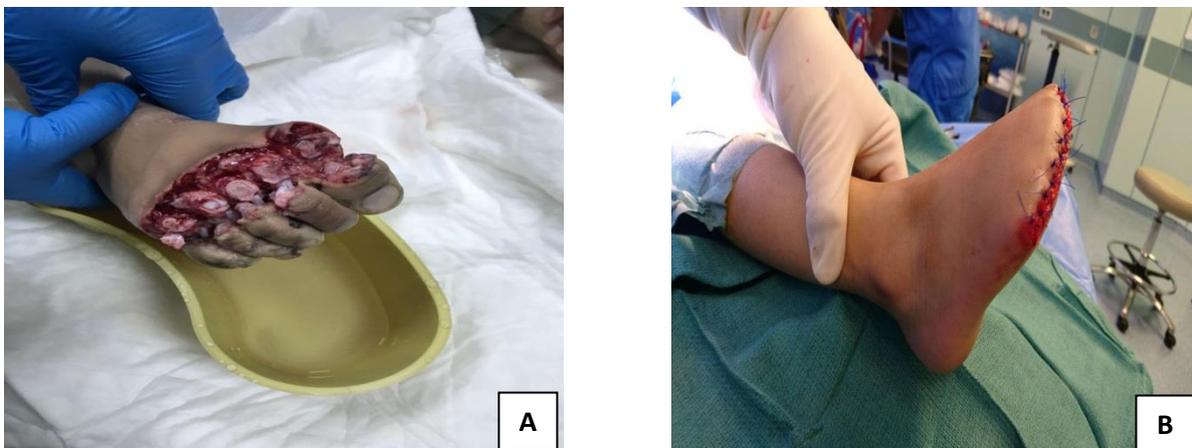
study included all children who are 14 years old and younger and were riding the ATVs alone or accompanied by someone else and were admitted through the emergency room (ER) to our institute (Level 1 trauma center) in King Abdullah Specialist Children's Hospital, Riyadh Saudi Arabia. Patients' chart and radiographs were reviewed to record patient demographics, type of injury, associated injuries, mechanism of injury, hospital course and the outcome. All incomplete information's were collected by contacting the family by phone. Microsoft Excel version 2016 was used for data entry and IBM SPSS version 20 for data analysis.

**RESULTS**

The study gathered 49 cases. The mean age was 3 years 9 months with a range of 1 year 6 months to 10 years. Thirty-four (69.3%) patients from both gender were 4 years or younger. Thirty-one (63.2%) patients were male and eighteen (36.7%) patients were female, giving male to female a ratio of (1.7:1). Four (8.1%) patients were riding the ATV alone (age 3-7 years). Sixteen (32.6%) patients were riding the ATV accompanied by their parents ( 7 were in the front seat and 9 were in the back seat). Twenty nine (59.1%) patients were riding the ATV accompanied by young relatives (6 were in the front seat and 23 were in the back seat). All patients had the same mechanism of

injury where the right foot trapped in the ATV's uncovered chain. All patients had an isolated right foot injury without any serious associated injuries. The average time of presentation to ER was 3 hours 20 minutes with a range of 15 minutes to 24 hours. All patients were riding the ATV in the desert. Eight (16.3%) patients were wearing shoes. Fifteen (30.6%) patients were wearing sandal, 9 (18.3%) patients were wearing socks only, and 17 (34.6%) patients were barefooted. All cases had a partial or complete amputation of one or more toes (Fig.1). Eight (16.3%) patients had a complete amputation, and 41 (83.6%) had a partial amputation, where some soft tissue connection remains. Twenty three (46.9%) patients had other minor associated foot injuries.

Table 1 shows description of the injury with the treatment outcome. Wearing sandal or socks only or being a barefooted had 42.8% risk of having other associated injuries and 10.2% risk of complete amputation. Whereas, wearing shoes had 4% risk of having other associated injury and 6.1% risk of complete amputation. All cases had irrigation and debridement under general anesthesia. In 41 patients, fixation was achieved initially with Kirschner wires (K-wires) (Fig.2). Fifteen (30.6%) patients needed a skin graft. Table 2 shows numbers and percentages of different risk factors.



**Fig. 1. Photographs show injury to all toes at the level of proximal phalanx with discoloration of the toes that lacked distal peripheral circulation and ended by amputation. (A) Pre-op, (B) Post-op.**



**Fig. 2. Photographs show injury to big toe and 2<sup>nd</sup> toe that had debridement and K-wires fixation. (A) Pre-op, (B) Post-op, and (C) One week Post-op.**

**Table1. Descriptive summary of ATV-related foot amputation.**

Case	Age	Injury	Associated Injury	Outcome
1	2 Y	- Crush injury of the right proximal phalanx of 5th toe and distal phalanges of 3rd, 4th with complete amputation	NO	Amputated 5th toe and distal phalanx of 3rd, and 4th toes
2	2 Y	- Crush injury of distal end of the right 1st toe with partial amputation	NO	Amputated 1st toe
3	5 Y	- Crush injury of right 1st and 2nd toes with partial amputation	NO	Amputated 1st toe
4	3 Y	- Crush injury of right phalanx of the 1st and 5th toes with complete amputation	NO	Amputated toes
5	4 Y	- Crush injury of all toes of right foot with complete amputation	NO	Amputated toes with skin graft
6	10 Y	- Crush injury of right 1st toe with partial amputation	Fracture of right midshaft diaphyseal femur	Amputated with skin graft
7	3 Y	- Crush injury of right 1st toe and middle of the right proximal phalanx with partial amputation	Fracture of right 2nd proximal phalanx	Amputated 1st toe
8	3 Y	- Crush injury of all toes of right foot with partial amputation	NO	Amputated toes
9	4 Y	- Crush injury of right 1st toe with partial amputation	Fracture of right proximal phalanx 1st toe	Amputated 1st toe
10	2 Y	- Crush injury of 1st toe with partial amputation	Fracture of right proximal phalanx of 1st, 2nd, 4th, and 5th toes	Amputated 1st toe with skin graft
11	3 Y	- Crush injury of all right five toes with partial amputation	Fracture of right 5th metatarsal neck	Amputated toes with skin graft
12	5 y	- Crush injury of all right five toes with partial amputation	Fracture of right 2nd, and 3rd metatarsal neck	Amputated toes
13	4 y	- Crush injury of distal phalanx of 1st toe with complete amputation and partial amputation of 3rd toe	NO	Amputated toes
14	5 y	- Crush injury of right foot metatarsal with partial amputation	NO	Amputation of forefoot with skin graft
15	2 years 3 months	- Crush injury of right 1st toe with partial amputation	NO	Amputated 1st toe
16	3 years 3 months	- Crush injury of right foot with partial forefoot amputation	Fracture of right 2nd, 3rd, 4th, and 5th metatarsal bones	Amputation of forefoot
17	3 y	- Crush injury of right 1st, 3rd, 4th, and 5th toes with partial amputation	NO	Amputated toes
18	4 y	- Crush injury at the level of interphalangeal and metatarsal with partial amputation	Fracture of right 2nd and 3rd metatarsal bones	Amputation of forefoot with skin graft
19	3 y	- Crush injury of right 1st toe with complete amputation	NO	Amputated 1st toe
20	2 y	- Crush injury of right 1st and 2nd toes with partial amputation	NO	Amputated toes
21	2 y	- Crush injury of right 1st toe and distal phalanx of 2nd toe with complete amputation	NO	Amputated 1st and 2nd toes
22	2 years 5 months	- Crush injury of right 1st toe with partial amputation	NO	Amputated 1st toe
23	6 Y	- Crush injury of right 1st, 2nd and 3rd toes with partial amputation	NO	Amputated 1st, 2nd and 3rd toes
24	4 Y	- Crush injury of right 1st, and 4th toes with complete amputation	Type 1 salter-harris fracture of right proximal phalanx of 4th toe	Amputated 1st and 4th toes
25	6 Y	- Crush injury of right 1st distal phalanx with partial amputation	NO	Amputated 1st toe
26	3 Y	- Crush injury of right 1st, and 2nd toes with partial amputation	Fractures of right proximal phalanx of 1st, 2nd, 3rd and 4th toes	Amputated 1st and 2nd toes
27	3 Y	- Crush injury of all right five toes with complete amputation	Fracture of right distal portion of the of the 4th metatarsal bone	Amputated all five toes
28	5 Y	- Crush injury of forefoot with partial meta-tarsal amputation	Fracture involves all proximal phalanges of the right foot	Amputated all five toes
29	2 years 10 months	- Crush injury to all toes with partial amputation	Fracture of right proximal phalanx of 5th toe	Amputated 5th toe with skin graft
30	5 Y	- Crush injury to forefoot with partial transmetatarsal amputation	NO	Amputated 1st, 2nd, 3rd, and 4th toes with skin graft
31	4 years 6 months	- Crush injury to forefoot with partial 2nd, 3rd, 4th, and 5th toes amputation	Fracture of right 5th metatarsal + middle phalanx of other toes	Healed wound
32	4 Y	- Crush injury to forefoot with partial 2nd, 3rd, 4th, and 5th toes amputation	NO	Amputated 2nd toe with skin graft
33	3 Y	- Crush injury to forefoot with partial 1st and 2nd toes amputation	NO	Amputated 1st toe
34	7 years 3 months	- Crush injury to forefoot with partial 1st toe amputation	NO	Amputated 1st toe
35	2 years 6 months	- Crush injury to forefoot with partial 1st, 2nd, 3rd, and 4th toes amputation	NO	Amputated 1st toe with skin graft
36	4 years 3 months	- Crush injury to all toes with partial amputation	Fracture of right proximal phalanx of all toes + dislocation at DIPJ	Amputated toes
37	5 years 2 months	- Crush injury to forefoot with partial 2nd, 3rd, 4th, and 5th toes amputation	NO	Amputated with skin graft
38	1 year 6 months	- Crush injury to all toes with partial amputation	NO	Amputated toes
39	2 years 6 months	- Crush injury to all toes with partial amputation	Fracture of right distal phalanx of all toes	Healed wound
40	2 Y	- Crush injury to forefoot with complete 1st, 2nd, and 3rd toes amputation	Fracture of right distal phalanx of 4th toe	Amputated with skin graft
41	1 year 7 months	- Crush injury to forefoot with partial 1st, 2nd, 3rd, and 4th toes amputation	NO	Amputated with skin graft

42	3 Y	- Crush injury to forefoot with partial 1st, 2nd, 3rd and part of 4th toes amputaion	Fracture of right proximal phalanx of 1st, 2nd, and 3rd toes + distal phalanx of 4th toe	Amputated toes
43	3 Y	- Crush injury to forefoot with partial 1st and 2nd toes amputaion	NO	Amputated 2nd toe
44	8 Y	- Crush injury to forefoot with partial 1st, and 2nd toes amputaion	NO	Amputated toes
45	7 Y	- Crush injury and degloving injury to forefoot with partial 1st, 2nd, and 3rd toes amputaion	Fracture of right 1st, 2nd, and 3rd MT bones	Skin graft to the dorsum of the foot
46	7 Y	- Crush injury to forefoot with partial 2nd, 3rd, 4th, and 5th toes amputaion	1st MT head fracture+ 2n, 3rd, 4th MTPJ dislocation + 5th PIPJ dislocation	Amputated toes
47	3 Y	- Crush injury to forefoot with partial 1st, 2nd and 3rd toes amputation	Fracture of right distal phalanx 2nd and 3rd toes	Amputated toes with skin graft
48	2 years 5 months	- Crush injury to forefoot with partial 1st, 2nd toes amputaion	2nd toe doslocation at DIPJ	Healed wound
49	1 year 6 months	- Crush injury to forefoot with partial 1st, 2nd toes amputaion	Dislocation of PIPJ of 1st toe and right middle phalanx fracture of 2nd toe	Healed wound

MT: metatarsal head, MTPJ: metatarsal phalangeal joint, PIPJ: proximal inter-phalangeal joint, DIPJ: distal inter-phalangeal joint

## DISCUSSION

The continuing use of ATV as a recreational vehicle for children under the age of 14 years become a threat to many societies who don't have a strict legislation or safety regulations for the ATVs use. Multiple injuries of the body were identified in young riders of ATVs including extremity fractures and amputations, torso and brain injuries.<sup>8</sup> However, children have greater risk compared to adults with wide variety of injuries in children identified other than foot amputation. ATV-related injuries can be life threatening. For instance, Head and neck followed by thoracoabdominal injuries, extremity and vascular injuries are the primary cause of death for children in ATVs crush.<sup>9</sup> Another international study noticed the annual incidence of victims and severity of ATV-related injuries in North America had increased in recent years due to the lack of regulation enforcement and public awareness of the danger of ATV use in children.<sup>10</sup>

Most of the patients in our study are four years of age or younger. The mean age here is lower than different multiple case series studies where most of them have a mean age of 11 years.<sup>7,11</sup> This makes the younger age (0 - 4 years) under extreme danger of getting feet injuries and amputations. The shorter lower extremities make them unable to reach the floorboards of the vehicle; and ends up with foot caught in the exposed chain. ATV safety should include chain protection that is not available in most of the vehicles here because the rules are not enforced enough and properly followed. Almost all the studies pointed to the young age of the driver with a lack of the appropriate safety equipments.<sup>12</sup>

However, position on ATV has a major role where the child who rides the ATV alone has a more chance to avoid foot injuries. The study shows only 4 patients (8.1%) were riding alone compared to 45 patients that were accompanied by another passenger. A passenger in the back seat has limited and less control in the vehicle while the driver in front holds the handgrip and controls the direction of the vehicle. Based on this study riding ATV for children with other teenagers has almost double the risk of foot injury and is even more dangerous than riding with their parents. Type of footwear is also important as wearing proper shoes will lead to less serious foot injuries and decrease the chances of other associated injuries. However, patients who were wearing either sandal or socks or being a barefoot are more prone to get injured and get the foot amputated.

It is quite depressing to find out that these severe injuries ending with amputations in such young children are preventable and we are not able to do so. All of them were injuries to the right foot caused by uncovered chain, quiet a simple solution that can prevent these devastating injuries can be enforced by the law. Regular periodic checkup for the vehicles' safety is very important with confiscation of the vehicle that doesn't match the standers as a penalty. Also, the lessor of these vehicles should be provided by all the important safety instructions such as prohibiting the riding of small children in the front along with all the important safety equipment (Fig.3).



**Fig.3: Photograph shows the proper way to ride ATV, considering the size of the child and all the safety equipment.**

There are multiple limitations of this study. The retrospective study design didn't allow us to collect a full data from the medical records regarding the details of each accident as well as other missing data that can be easily completed if we conducted the study prospectively. Furthermore, despite the long period that was chosen for this study, we had a small number of cases that limits our objectives. However, this study gave us a clear picture in short time that can help in generating another hypothesis for any similar future study as well to find an immediate solution for this dangerous sport. Unfortunately, after the last study that was

conducted in 2011 there were no much changes in the rules and we still receive many cases.<sup>4</sup> The current legislation of riding the ATV in children is definitely not enough. Strict regulation with law enforcement and public awareness are needed.

In conclusion, this study shows that ATV injuries are serious problem for young children in our society. Foot amputation and

other associated injuries are the end result of riding such vehicle without a proper regulation or safety measures.

The prevention of these injuries lies on both the law enforcement and the family awareness. Failure in any of these two, ATV injuries will continue to occur and affect many young children's limbs and maybe lifes.

**Table 2: Numbers and percentages of ATV-related foot amputation according to age, gender, position on ATV, and type of foot wear.**

		Male		Female		Total	
		No.	%	No.	%	No.	%
<b>Age</b>	<b>0 - &lt;5</b>	20	40.8	14	28.5	34	69.3
	<b>5 - &lt;10</b>	10	20.4	4	8.1	14	28.5
	<b>10 – 14</b>	1	2.0	0	0	1	2.0
<b>Position on ATV</b>	<b>Alone</b>	3	6.1	1	2.0	4	8.1
	<b>parental accompaniment</b>	11	22.4	5	10.2	16	32.6
	<b>non-parental accompaniment</b>	17	34.6	12	24.4	29	59.1
<b>Type of foot wear</b>	<b>Shoes</b>	4	8.1	4	8.1	8	16.3
	<b>Sandals</b>	10	20.4	5	10.2	15	30.6
	<b>Socks</b>	7	14.2	2	4.1	9	18.3
	<b>Barefoot</b>	10	20.4	7	14.2	17	34.6

#### ETHICAL CONSIDERATIONS

Since this is a retrospective chart review, no consent was needed from the patients. However, the patients' identities were coded. Ethical approval was received from King Abdullah International Medical Research Center (KAIMRC).

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