Musculoskeletal Trauma in Four-Wheeled All-Terrain Vehicles

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Abstract

A longitudinal study of four-wheeled all-terrain vehicle-related musculoskeletal injuries requiring orthopedic surgery was performed. Avoidable risk factors such as alcohol intake, lack of helmets, inexperience, and excess speed were identified. This study also shows that the quantity, severity, cost, and frequency of preventable accidents while riding continue to be the same as prior to a Consent Decrees issued by the Consumer Products Safety Commission >10 years ago.

Four-wheeled all-terrain vehicle accidents are a common cause of musculoskeletal injury. Since their invention in the early 1970s, all-terrain vehicles have become one of the most dangerous vehicles designed due to a high center of gravity, poor or absent suspension systems, and no rear differentials.

Four-wheeled all-terrain vehicles give an illusion of inherent stability with a four-wheeled platform and oversized tires. This is all complicated by preventable risk factors such as rider inexperience, alcohol intoxication, excessive speed due to lack of a speedometer, and riding without a helmet, which often are disregarded by riders. In 1987, Dolan et al reported approximately 300,000 injuries and 900 deaths were attributed to the use of all-terrain vehicles.

In 1988, the Consumer Products Safety Commission and all manufacturers of all-terrain vehicles signed a legally binding Consent Decrees designed to decrease the number of all-terrain vehicle-related deaths and injuries. The Consent Decrees lasted from 1988-1998 and included the following provisions:

- Cease production and sale of new three-wheeled all-terrain vehicles without recalling old models.
- Implement a national rider safety-training program.
- Institute a voluntary development of industry standards to make them safer.
- Enforce warnings and age recommendations on vehicle advertising.
- Enforce that all-terrain vehicles with engines >70 cc only be used by children aged >12 years, and vehicles with engines >90 cc were not to be used by children or adolescents aged <16 years.

This article presents a retrospective study of the nature and severity of four-wheeled all-terrain vehicle accidents with musculoskeletal injuries requiring orthopedic surgical treatment in a level I trauma center.

Materials and Methods

This study includes all patients admitted to our institution who required orthopedic surgical treatment due to all-terrain vehicle trauma between May 1998 and May 2000. These cases were analyzed for age, gender, weight, height, anatomic location of trauma, associated injuries, position in all-terrain vehicle (driver, passenger, or pedestrian), injury mechanism, drug or alcohol use, driving experience, engine size, helmet use, treatment, length of stay, treatment cost at the acute stage, complications, and outcome.

Thirty-three patients (26 males and 7 females) with a total of 46 musculoskeletal injuries that required orthopedic surgical treatment were included in the study. Mean patient age was 23 years.
Figure 1: Distribution of skeletal injuries secondary to four-wheeled all-terrain vehicles.

years (range: 10-69 years). Mean weight was 149 lbs (range: 75-180 lbs), and mean height was 5'6" (range: 4'6"-6'0").

RESULTS

The anatomic location of injury is distributed as upper extremity, lower extremity, and axial skeleton. Trauma to the upper extremity included the following fractures: 1 humerus, 4 elbow, 1 ulna, 1 distal radius-ulna, 5 metacarpals, and 1 middle phalanx. Lower extremity injuries included: 1 intertrochanteric fracture, 1 irreducible hip dislocation, 7 femur fractures, 2 patellar fractures, 1 open knee joint, 1 tibial plateau fracture, 13 tibia fractures, 1 triplane fracture, 1 medial malleolus fracture, and 1 peroneus brevis tendon transection. Axial skeleton injuries included 3 acetabular fractures and 1 L1 fracture (Figure 1).

Of 43 fractures, 32 were closed and 11 were open. According to Gustilo et al.,2 supraintercondylar open fractures were classified as type I, 6 tibia fractures type II, 1 patella type II, 1 metacarpus type II, and 1 open middle phalanx fracture type III B.

Twenty-four (73%) patients were driving at the time of the accident, while 8 (24%) were riding as passengers and 1 (3%) was a pedestrian. Two (6%) patients fell from the all-terrain vehicle. Ten (30%) patients sustained trauma against a moving object and 20 (61%) experienced trauma against a stationary object.

All patients denied being under the influence of drugs, however 11 (33%) patients admitted to being under the influence of alcohol. Thirteen (40%) patients had no previous experience with all-terrain vehicles, 5 (15%) had <6 months’ experience with the vehicle, and 15 (45%) patients had >6 months’ experience. Only 4 (12%) patients were wearing helmets at the time of the accident. More than two thirds of the vehicles were 350 cc, some with homemade alterations to increase horsepower.

The average length of patient stay was 11 days (range: 2-44 days). Three patients required hospitalization in the intensive care unit due to associated head trauma and lung contusions. Twenty patients with femoral and tibial shaft fractures were treated with immediate intramedullary nailing, and 12 patients required open reduction and internal fixation of their fractures. Three closed reductions and skeletal traction in 3 acetabular pediatric fractures were performed. One comminuted distal radius fracture was treated with external fixation and bone graft. An irreducible hip dislocation with an associated ipsilateral femur fracture was treated by emergent closed reduction of the hip and retrograde intramedullary nailing of the femur fracture. One L1 burst fracture with a large retropulsed fragment, without neurological deficit, was managed with anterior and posterior spinal fusion with instrumentation and bone graft. All open fractures required debridement.

There were five complications. The mid-phalanx fracture was seen at follow-up and the skin was devitalized with exposed bone, requiring a ray amputation. Three tibia nonunions required further surgery, and one tibia infection required an exchange nailing, in addition to a rotational flap during another hospitalization.

Ambulance transport, emergency room evaluation and treatment, hospital admission, intensive care, and operative costs were all included in the total cost of treatment. The average cost was $11,804 (range: $3309-$54,622).

DISCUSSION

In this era of injury prevention, identifying potential sources of major morbidity and mortality is important.6 The only known orthopedic literature about these accidents is an editorial by Cowell3 based on an article by Pyper and Black.2 After reviewing the literature, several studies were found with similar results with respect to gender, age, helmet use, length of stay, costs,
alcohol intake, driving experience, and speed.5,8,1,11,12

Studies from a variety of geographical locations, such as Canada,2 Virginia,4 Pennsylvania,5 Georgia,6 Arizona,7 Missouri,8,12 and New Mexico,13 report results similar to this case. The typical patient is a male in his early twenties driving without experience without a helmet at excess speed under the influence of alcohol. This concurs with the other studies reviewed.2,4-7,12,13

Musculoskeletal trauma caused by all-terrain vehicles puts an economical burden on medical care. Patients usually remain disabled for several weeks to months due to their fractures.2,4,6,8 Our results, with respect to length of stay and the cost of treatment, were comparable to those published in the literature.5,7,8,12 As expected, costs were higher for patients with associated nonorthopedic trauma. The severity of musculoskeletal trauma caused by these vehicles explains the high cost of treatment. Factors such as length of stay, implants, and numerous procedures increase the cost of treatment. Our cost numbers did not include the price of lost wages and medical equipment used by patients after the accidents.

The lower extremity accounts for 63% (29/46) of all injuries in our series, as in the Pyper and Black’s study, with a total of 4 knees, 7 femoral shafts, and 13 tibiofibulas, 2 of which were floating knee lesions. One of the fractured femurs had an ipsilateral hip dislocation that underwent close reduction. The tibial plateau fracture was a Shatzker type VI that required open reduction and internal fixation and bone graft, 1 triplanar fracture, 1 medial malleolous fracture, and 1 peroneus brevis tendon transsection injury with considerable soft-tissue damage.

In accordance with Greene and Metzler’s12 study, full height motorcross-type boots are recommended to protect the lower extremities. The fact that the lower extremities sustained trauma more commonly should address the design and ergonomics of the four-wheeled all-terrain vehicles as well as their power. When the Consent Decrees was issued in 1988, an adult all-terrain vehicle was considered to be ≥90 cc. None of the vehicles in our series had engines with <250 cc of displacement, and three patients who had associated injuries were driving 350-cc vehicles.

Injuries to the pediatric population have been attributed to underdeveloped motor skills and the overall level of coordination, as well as the inherent instability of the vehicles.8 Eighteen percent of patients in our study were children. The literature states that 47% of the injuries in 1997 were in children aged <16 years; however, this study represents only 18%, with three comminuted acetabular fractures, one femur fracture, and one triplanar fracture. This percent difference is explained by the fact that other studies include abrasions, lacerations, and clavicle and extremity fractures that do not require surgical treatment and that are common and less serious.1

Children suffer the most severe injuries.4,5 The only upper extremity injury in this population was in a 10-year-old girl who impacted a static object while driving her father’s 350-cc four-wheeled vehicle. This patient did not fall from the vehicle; she hung on to the manubrium with both elbows fully extended sustaining a bilateral supracondylar fracture, and one elbow had a medially located puncture wound (Figure 2).

Only four (12%) patients were wearing helmets when they experienced their accident, and none sustained head trauma. This finding correlates with other series that reported the limited use of helmets—only 7%2,4 to 12%.8,11 of patients were using them. The low incidence of head trauma in our series can be explained by the study methods. All patients without operative musculoskeletal trauma were excluded. The high mortality caused by head trauma without a helmet is reported in the literature.5,4,6,11

This study confirms the high-risk nature of four-wheeled all-terrain vehicles. It also shows that driving all-terrain vehicles under the influence of alcohol is even more dangerous. Patients with severe trauma, requiring admission to the intensive care unit, were under the influence of alcohol, in addition to being inexperienced riders without helmets. The oldest patient was a 69-year-old woman pedestrian who was impacted, sustaining a severely comminuted patellar fracture.

It is difficult to attribute these injuries only to design failure of the vehicle. Preventable risk factors such as rider inexperience, intoxication, excessive speed, and lack of helmets need to be recognized.

**Conclusion**

This study was performed 2 years after the Consent Decrees 10-year period expired. The quantity, severity, and frequency of accidents while riding, and even walking near these vehicles, continues to be the same as prior to when the Consent Decrees was issued. Patients sustaining these injuries had several preventable risk factors in common. If these factors are avoided through proper education, musculoskeletal injuries could be prevented or diminished.

Orthopedic surgeons should com-
municate the health hazards of these vehicles to patients and recommend the use of full body protective equipment. In addition, a re-evaluation of modern four-wheeled all-terrain vehicle tests should be performed by corresponding government agencies.

REFERENCES