

A new etiological cause for anterior cruciate ligament injury: E-Scooter

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The usage of electric scooters has been popular because it is a cheap and fast transportation method. Its use has increased in recent years because public transportation is less preferred during the covid-19 pandemic and in parallel, the publications reporting e-scooter accidents are increasing. There is no article examining the relationship between e-scooter and anterior cruciate ligament (ACL) injury in current literature. We aim to examine the relationship between e-scooter accidents and ACL injury incidence. Patients over the age of 18 years who applied to our orthopedics outpatient clinic with the diagnosis of ACL injury between January 2019- June 2021 were evaluated. 80 e-scooter accidents resulting with ACL tears were reviewed. The electronic medical records of the patients were reviewed retrospectively. Information about the age, gender, trauma history of the patients, and type of trauma was obtained. Fifty-eight patients had a history of falling while stopping the scooter, and 22 patients had a history of falling after hitting something. Anterior cruciate ligament reconstruction was performed with hamstring tendon grafts in 62(77,5%) of the patients included in the study. 18 (22,5%) patients were followed up with functional physical therapy exercises because they did not want to be operated on. Various bone or soft tissue injuries while using e-scooters have been reported in the literature until now. ACL injury is also seen quite frequently after these traumas, and necessary information and warnings should be given to the users to prevent ACL injuries.

Keywords : E-scooter, etiology, anterior cruciate ligament injury, falling, accident.

INTRODUCTION

Electric scooter (e-scooter) has become popular short-distance public or private transportation method due to the development of mobile payment methods. E-scooters are more compact structures among other micro-mobility services, including docked and dockless bikes or electric bikes (e-bike)⁹. The use of devices known as the ancestors of modern scooters dates to 1915. The popularity of scooters has grown in recent years with the introduction of electric, rentable, and highly mobile vehicles called e-scooters⁸. Being cheap and easily accessible is the most important reason for preference withal some people who care about the environment emphasize the feature of being electric. The use of these vehicles, which entered our social life with the concept of micro-mobility, increased during the Covid 19 pandemic^{9,17}. Individuality became more prominent, the use of public transportation vehicles decreased during the pandemic period and so the popularity of personal mobility devices (PMDs) increased. PMDs bring convenience to travel but they also cause problems like usage efficiency, problems that arise

with parking on sidewalks, and being a potential trauma reason for pedestrians as well as scooter drivers. The number of accidents and injuries related to the use of PMDs is increasing day by day although most countries set criteria to be followed during the use of PMDs.

After starting the active usage of e-scooters in the USA in September 2017, studies on injuries caused by e-scooters began to spread¹⁶. It is almost agreed that this new type of injury, in which craniocerebral injuries are mostly seen, should be considered a high-energy trauma because the use of the protective gear is very low¹⁵. There is no study in the current literature investigating the relationship between e-scooter use and anterior cruciate ligament (ACL) injury incidence as far as we know. We aim to reveal whether there is a correlation between the increase in e-scooter use and anterior cruciate ligament injury. We hypothesize that the use of e-scooters without the use of protective equipment increases the incidence of ACL injury and therefore increases the burden on the use of healthcare resources.

MATERIALS AND METHODS

This single-center retrospective cohort study was conducted between January 2019 and June 2021. The electronic medical records of patients over the age of 18 who applied to our orthopedics outpatient clinic with the diagnosis of ACL injury were reviewed retrospectively. Information about the age, gender, trauma history of the patients, and trauma etiologies were obtained from the patient electronic medical files. The indication for anterior cruciate ligament surgery was decided by evaluating the symptoms, evaluating the activity levels of the patients, and discussing their occupational and post-surgical expectations with the patient.

Radiological images were obtained from the Extreme-Pacs TM imaging system. 80 patients who were found to have anterior cruciate ligament injuries during e-scooter driving were included in the study. Our study has been approved by our ethics committee with the number 299 and has therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

RESULTS

680 patients diagnosed with ACL tears were included in the study. 378 were male (55%) and 302 were female (45%). ACL tear etiology was sports injuries in 234 patients (34%), traffic accidents in 138 patients (20%), falls in 58 patients (9%), work accidents in 47 patients (7%), e-scooter accidents in 80 patients (12%). 123 patients did not remember the etiology (18%). Fifty-eight patients had a history of falling while stopping the scooter (non-contact) (72.8%), and 22 patients had a history of falling after hitting something (contact) (27.2%) as a result of the evaluation of injuries caused by the e-scooter. 52 of the patients (65%) were male and 28 (35%) were female. The mean age of the patients was 38.4 years (19-52). Anterior cruciate ligament integrity was evaluated radiologically and clinically with magnetic resonance imaging (MR) and physical examination (pivot-shift) findings performed by 2 experienced orthopedists. Anterior cruciate ligament injury occurred in the non-dominant extremity in 42 (72.4%) of 58 patients with a history of falling with an e-scooter, the dominant extremity was injured in 16 (27.6%) of them. Anterior cruciate ligament injury occurred in the non-dominant extremity in 2 (9%) of 22 patients with a history of collision with an e-scooter, the dominant extremity

was injured in 20 (91%) of them. Fifty-eight patients who were injured by non-contact mechanism had 24 lateral meniscus, 8 medial meniscus and 3 bilateral meniscus tears. Of 22 patients with contact injury, 4 had lateral and 3 had medial meniscal tears. Osteochondral lesions were more common in these patients. Osteochondral lesions were detected in the medial condyle in 6 patients and the patella in 4 patients.

In order to reduce the risk of arthrofibrosis⁴ and to enable patients to have a comfortable recovery period after fracture surgery, anterior cruciate ligament reconstruction operations were attempted within 3-6 months after trauma. Anterior cruciate ligament reconstruction was performed with autologous hamstring tendon grafts in 62 (77,5%) of the patients included in the study. 18 (22,5%) patients who didn't want to have surgery were followed up with functional physical therapy exercises because they did not want to be operated on.

Fourteen of 80 patients had upper extremity fractures accompanying anterior cruciate ligament injury. In these patients, distal radius fractures, radial head fractures, and, less frequently, distal humerus fractures were detected. There were lower extremity fractures in 6 patients, 4 patients with malleolar fractures, and 2 patients with patella fractures. Since ACLR surgeries are performed electively within 3-6 months after trauma, fracture surgeries were planned according to the general condition of the patient and performed in the early period.

DISCUSSION

ACL injuries are mostly (70%) caused by non-contact injuries¹. Electric scooters, the use of which has increased even more after the Covid-19 pandemic, have begun to emerge with a new non-contact injury mechanism in ACL injuries. Electric scooter use is a preventable mechanism of ACL injury by taking simple precautions.

The incidence of anterior cruciate ligament injuries increases every year compared to the previous year due to the increase in participation and interest in sports all over the world². Primary costs caused by surgeries also put a burden on the health system along with the increase in anterior cruciate ligament injuries. Considering that the use of PMDs has increased even more during the Covid-19 pandemic period, it is obvious that these new surgical expenditures will put into difficulties the health economies that have been already strained due to Covid-19^{9,17}. The publications

about PMDs and especially e-scooters are increasing exponentially. These publications are mostly about general body trauma and there is no publication in the literature regarding the e-scooter-related anterior cruciate ligament injury incidence as far as we know.

The rapid adoption of e-scooter usage, which gained popularity with its features such as ease of use, low cost, and being environmentally friendly, brought serious injuries as well. Ishmael et al. reported 73 e-scooter trauma-related patients with injuries serious enough to require orthopedic surgery⁷. Hourston et al. reported cases of e-scooter traumas requiring surgical intervention in 50% of the patients over 2 years in their study⁶. Shichman et al. detected a total of 716 fractures in 563 patients who had e-scooter-related injuries between May 2017 and February 2020¹⁴. 46.4% of these patients were hospitalized and operated on.

We think that the type of trauma is directly related to the severity of the trauma. The trauma mechanism was explained in 2 ways as falling or collision with vehicles. 89.2% of the traumas causing upper extremity fractures were caused by rider fall mechanism, while 15.7% of traumas causing lower extremity fractures were caused by rider-vehicle collisions¹⁴. In our study, anterior cruciate ligament injury occurred in 80 patients due to e-scooter-related trauma. 58 patients (72.8 %) had a history of falling while stopping the scooter, and 22 patients (27.2 %) had a history of anterior cruciate ligament rupture because of falling after rider-vehicle collisions in our study.

The vast majority of anterior cruciate ligament injuries (approximately 75%) occur after non-contact injuries¹⁸. Fifty-eight of our 80 patients (72.8 %) included in our study had a history of trauma due to not releasing the hand throttle when trying to stop the scooter. An anterior cruciate ligament injury may occur because of the femur coming forward while the tibia is fixed, as the inexperienced drivers do not slow down by releasing the throttle while one foot touches the ground to stop the scooter. The coronal force acting on the extremity (fixed on the ground) continues as the driver doesn't release the hand throttle and causes knee valgus. The scooter continues to move, and the knee fixed in the valgus remains behind. It causes additional rotational forces (sagittal and transverse) to act on the anterior cruciate ligament. This movement may cause damage to the anterior cruciate ligament by producing valgus knee at the same time with twisting movement (Figure 1).

The second mechanism for anterior cruciate ligament injury mechanism was contact injury in 22 of our patients (27.2%). The collisions in our patients included in the study were mostly in the form of inanimate objects such as trees (8 patients- 36.4 %) or hitting the pavement after falling (14 patients- 63.6 %). Although the number of articles published in the literature on e-scooter-related injuries is increasing day by day, as far as we know, there is no publication in the literature on its relationship or the mechanism with an anterior cruciate ligament injury.

The position of the extremities during e-scooter use may affect the injured extremity. The first step to getting

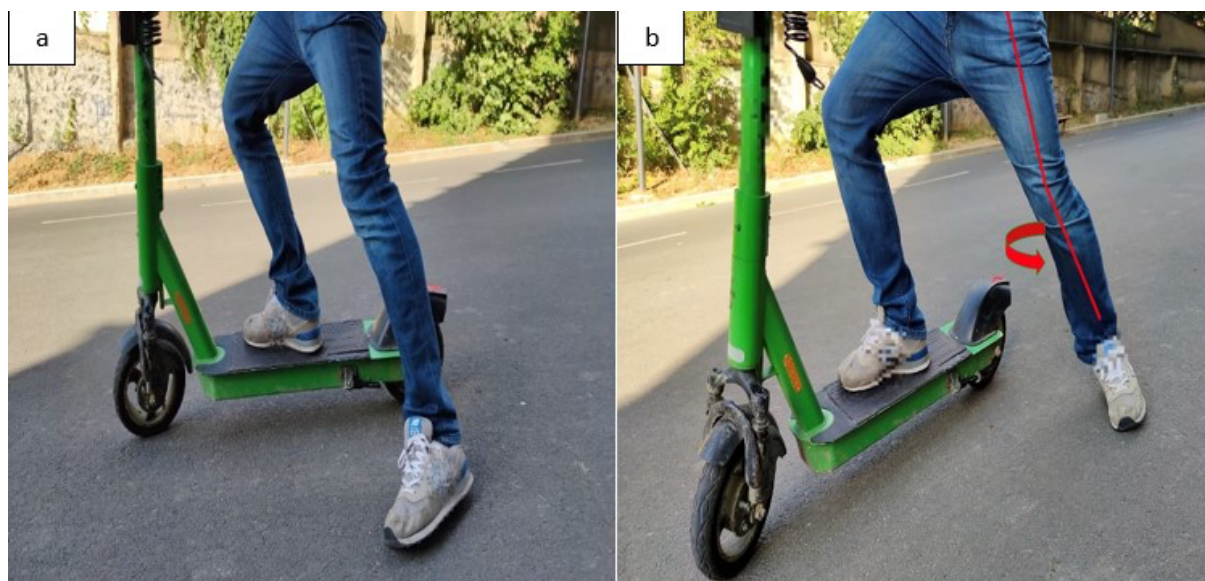


Fig. 1 — The mechanism of injury of the anterior cruciate ligament due to the formation of valgus and rotation in the knee during falling (a) lateral (b) anterior view.



Fig. 2 — The riding position of scooter users.

the e-scooter engine moving is to push it with the foot that is not on the footrest. According to the anamnesis of our patients, the foot used for the first movement to the electric motor is generally the non-dominant foot. The dominant foot is used on the footrest to provide body balance. The scooter users position their feet to stay balanced while increasing the scooter speed by using the electronic throttle. In the standing position on the footrest, while the dominant foot is in front, the non-dominant foot stands behind the dominant foot after giving the e-scooters' first move (Figure 2). The leg behind facilitates the push-off to accelerate if needed or to make a foot brake by pressing on the mudguard of the rear wheel. In our study, regardless of the trauma mechanism (falling or hitting), the non-dominant extremity was injured in 44 patients (55%) and the dominant extremity was injured in 36 patients (45%). While it was observed that 91% of the injuries caused by the impact were in the dominant extremity, on the contrary, it was concluded that the rate of injury with the non-dominant extremity in fall injuries was 72.4%. In fall injuries, rotation of the non-dominant foot standing behind the footrest with contact with the ground increased the risk of injury.

None of our patients participating in our study were using protective equipment while using an e-scooter. The most important way to prevent more serious and fatal accidents such as head and face trauma is the use of a helmet. According to the studies^{8,12,13}, the use of helmets is very rare, between 2-4%, and the use of protective equipment decreases as age decreases.

Similarly, in a study conducted on roller skaters, it was found that the use of wrist guards, which are known to reduce severe upper extremity fractures and soft tissue injuries, is very low⁵. While skateboard and hoverboard injuries mostly cause upper extremity injuries, we frequently see lower extremity injuries together with upper extremity injuries almost at the same rate as e-scooter injuries^{5,11}. Scooter drivers must carry their personal equipment with them to use protective equipment. The difficulty of transporting this equipment and the fact that e-scooters are picked up from where the previous users left off (no rental station) reduces the use of equipment. The inability to use protective equipment stands as the biggest obstacle to the prevention of e-scooter-related accidents.

A new regulation was made in our country on April 14, 2021, due to the increase in e-scooter-related cases¹⁹. Scooters can travel at a maximum speed of 25 kilometers per hour according to the new regulation. The age limit for use was also set at 15. E-scooters were required to be used only on the bicycle path and their use on the pedestrian path was prohibited. Considering the countries where a significant decrease in the incidence of accidents was not detected despite several revisions in similar regulations, it is obvious that this regulation cannot solve this problem in our country^{3,10}. We think that raising awareness of scooter users, increasing awareness of this problem with the help of social media and television, and imposing strict penalties for those who do not comply with the rules can help solve the problem.

CONCLUSION

The paradox of the increasing number of people injured by e-scooters, which are preferred for environmental reasons, economic reasons, or just for fun, is an issue that needs to be considered. It is clear that injuries caused by the use of e-scooters, especially during the Covid pandemic period, bring additional economic damage to health institutions. We believe that making more restrictive and followed decisions regarding the use of protective equipment and e-scooter will reduce injuries.

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