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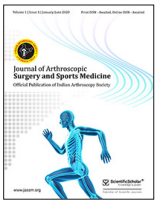

Original Article

Injury mechanism of knee medial collateral ligament: An online systematic video analysis

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ABSTRACT

Objectives: The medial collateral ligament (MCL), one of the main stabilizers of the knee, is also the most injured ligament of the knee. Isolated MCL injuries are common in young men who play contact sports. It was hypothesized that MCL rupture in professional athletes develops with a specific injury mechanism. Furthermore, body posture at the time of injury varies in different sports.

Materials and Methods: On May 15, 2021, "knee medial collateral injury" and "MCL injury" were entered in a YouTube® search. The inclusion criteria were to verify that the video was compatible with the injury, that the video included the foot, ankle, knee, hip, and the whole body at the time of injury, and that image quality was sufficient to detect the mentioned body parts. Exclusion criteria were non-MCL knee injuries, insufficient images, poor video quality, and additional injuries with MCL.

Results: Of the 23 injuries included in the study, 22 (95.7%) were male and 1 was female (4.3%). The distribution of activities in which injuries occurred was seven basketball (30.4%), four American football (17.4%), four ice hockey (17.4%), three soccer (13.0%) one water ski (4.3%), one skateboard (4.3%), two-track and field (8.6%), and one wrestling (4.3%). In 18 cases (78.3%), the injury occurred by contact. Of these, 16 were caused by direct contact (69.6%) and two by indirect contact (8.7%).

Conclusion: Isolated MCL injury occurs when valgus force is applied with the trunk flexed and turned towards the injured side, the hip abducted and slightly flexed, and the knee slightly flexed. The majority of these cases occur after a direct blow to the lateral knee.

Keywords: Medial collateral ligament, Knee, Injury mechanism, Professional athlete, Body Posture, Prevention

INTRODUCTION

The medial collateral ligament (MCL), one of the main stabilizers of the knee, is also the most injured ligament of the knee.[1-3] Isolated MCL injuries are common in young men who play contact sports (e.g. soccer, judo, skiing, wrestling, and hockey).[4] At the same time, increased participation in sports over the years has contributed to the increase in the frequency of these injuries.[5]

Isolated injuries to the medial side of the knee, especially the MCL, have received little attention in the literature.[4] This is primarily due to a focus on anterior and posterior cruciate ligaments as well as postero-lateral corner injuries.[4] Therefore, besides a discernible lack of evidence when looking at knee motion and muscle recovery following isolated MCL injury, there are still some concerns regarding the incomplete or underestimated clinical and radiographic findings of these injuries.[4,6]

Although these injuries cause loss of time in athletes, low-stage injuries of the MCL are often not reported.[2,6] Further studies are needed to elucidate the optimal treatment of MCL injuries as the demand for rapid recovery of patients to pre-injury activity levels, whether recreational or professional, is increasing.[7] The correct characterization of every aspect of injury will help determine the optimum treatment plan.[5] One of these aspects that can shed light on the treatment planning for MCL injury is knowing the most common injury mechanism.[2]

One of the methods used to determine an injury mechanism in detail is the video analysis method.[8] To the best of our knowledge, there is no video analysis study on the mechanism of MCL injury in the literature. In this study, the aim was to determine the body positions related to the mechanism of injury and the maneuvers that caused it by video analysis of isolated MCL injuries. It was hypothesized that MCL rupture in professional athletes develops with a

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specific injury mechanism. Furthermore, body posture at the time of injury varies in different sports.

MATERIALS AND METHODS

On May 15, 2021, "knee medial collateral injury" and "MCL injury" were entered in a YouTube® search.[9] All search results obtained were monitored. All videos found in the search were reviewed and approved by the three study authors. The inclusion criteria were to verify that the video was compatible with the injury, that the video included the foot, ankle, knee, hip, and the whole body at the time of injury, and that image quality was sufficient to detect the mentioned body parts. Exclusion criteria were suspicious injury videos, insufficient images, poor video quality, and additional injuries with MCL. After scanning, 31 videos with 29 injuries were found. One case was excluded because the whole body could not be seen in the video, three cases were due to non-MCL injury, one case due to poor image quality, and three cases were due to accompanying anterior cruciate ligament injury in the video description. The remaining 23 MCL injury videos were included in the study [Table 1]. This methodology has previously been used in recent research.[10,11]

The injury mechanism was analyzed into two categories non-contact and contact. Contact injuries, on the other hand, were divided into direct and indirect contact injuries. Direct contact injuries are those in which an external force was applied directly to the injured knee, whereas indirect contact injuries are those where the injury occurs without any contact at the knee or other level before or during the injury.[12]

A video analysis software was not used to examine each part of the video. Therefore, quantitative measurements were not performed. The videos were viewed by slowing them down to 0.25 speed. The above-mentioned authors examined the videos for the following: the presence of contact, play activity at the time of injury (take-off/acceleration, jump descent, jump, stop/turn), body position (neutral, flexion, and extension), body tilt (ipsilateral, contralateral), body rotation (ipsilateral and contralateral), coronal hip position (neutral, abduction and adduction), sagittal hip position (neutral, flexion, and extension), hip rotation (neutral, internal, and external), sagittal knee position (flexion and extension), coronal knee position (neutral, varus, and valgus), sagittal ankle position (neutral, dorsiflexion, and plantar flexion), coronal heel position (neutral, varus, and valgus), and foot position (neutral, pronation, and supination). Videos were evaluated blindly by all three authors. These data were analyzed statistically, and then intra- and inter-observer agreements were evaluated. The common position indicated by at least two observers in the obtained body positions was considered the correct position. In any case, where all observers indicated a different position, the three observers would watch the video together to make a joint decision. However, this did not occur in the course of this study.

Intra- and inter-observer agreement was investigated using the Fleiss kappa (k) statistics for categorical data. The inter-observer agreement percentages were calculated by dividing the number of occasions of the complete agreement by the total number of occasions. It was interpreted as follows: <0.00= poor agreement; 0.00–0.20= slight agreement; 0.21–0.40= fair agreement; 0.41–0.60= moderate agreement; 0.61–0.80= substantial agreement; and 0.81–1.00= almost perfect agreement. Statistical significance was set at $P < 0.05$. SPSS® version 23.0 was used in the statistical analyses.

RESULTS

Of the 23 injuries included in the study, 22 (95.7%) were male and one was female (4.3%). The right side was injured in five cases (21.7%) and the left side was injured in 18 cases (78.3%). The distribution of activities in which injuries occurred was seven basketball (30.4%), four American football (17.4%), four ice hockey (17.4%), three soccer (13.0%) one water ski (4.3%), one skateboard (4.3%), two-track and field (8.6%), and one wrestling (4.3%).

In 18 cases (78.3%), the injury occurred by contact. Of these, 16 were caused by direct contact (69.6%) and two by indirect contact (8.7%).

In the data obtained from the video recordings, the intra- and inter-observer agreement was substantial ($k = 0.790$, $P = 0.01$ and $k = 0.743$, $P = 0.01$, respectively). The game activity at the time of injury is summarized in [Table 2] and the features of the video analysis related to the mechanism of injury are summarized in [Table 3].

Basketball

The injury occurred in four of seven basketball players after contact. All contact injuries occurred after the opponent's direct lateral contact to the knee. One of these athletes hit their opponent on the descent after jumping to block the air ball and in another video, the opponent would fall on the athlete's knee after losing his balance. In the other two injuries, the opposing player applied a direct blow to the knee during a fight for the ball. One of the non-contact injuries occurred while the athlete was running, while the other two injuries occurred when falling as a result of the foot slipping on the floor.

Football

In all four football players, injuries occurred after direct contact with the opponent player in a fight for the ball. Two athletes had contact with the opponent during the fight, while two others lost their balance and fell on the athlete's knee.

Ice hockey

In three out of four athletes, injuries occurred through direct contact. One of these athletes was a goalie and was crouched with the knees touching the ice in extreme flexion to hold the puck. The injury occurred when an opponent fell on the

Table 1: Links to videos included in the study, video titles, and the type of sports activities in which the injury occurred.

Video number	Video link	Video title	Activity
1	https://www.youtube.com/watch?v=q5XZHGhRwlk	Stephen Curry MCL Injury|Hawks versus Warriors|March 23, 2018|2017-18 NBA Season	Basketball
2	https://www.youtube.com/watch?v=V-Vw5dP5liU	RUSSELL WILSON - MCL SPRAIN (Injury vs. 49ers) Week 3	American Football
3	https://www.youtube.com/watch?v=lr57dyxpeZQ	ThrowSwipe MCL Injury	Stunt Training
4	https://www.youtube.com/watch?v=SheTibVgqDY	Warriors Suffer Setback After Kevin Durant Sprains Knee Ligament	Basketball
5	https://www.youtube.com/watch?v=jtLw6cgEn0c	Doctor Reviews ZION Williamson Knee Injury|What Happened??	Basketball
6	https://www.youtube.com/watch?v=TLs9yizhJrE	Icemen versus Wildcard. MCL injury	Ice Hockey
7	https://www.youtube.com/watch?v=GvaqDd33JAA	Villanova - Collin Gillespie discusses his MCL injury	Basketball
8	https://www.youtube.com/watch?v=emjv467IkCg	Alex Morgan Knee Injury (Aug 7th, 2013)	Soccer
9	https://www.youtube.com/watch?v=6lkJDM5uqaQ	Leo Messi's knee injury in Barcelona - Las Palmas 2-1 Sep 26, 2015	Soccer
10	https://www.youtube.com/watch?v=iCUUQit4UC8	Ben MCL Injury	Barefoot Water Skiing
11	https://www.youtube.com/watch?v=W1z-DobF9yw	GameTime: Blake Griffin's injury to his left knee Sprained MCL - Nov 29, 2017	Basketball
12	https://www.youtube.com/watch?v=oAVOtrUiRxQ	Curry Injured right knee versus Houston Rockets! Suffers Grade 1 MCL knee sprain, out!!	Basketball
13	https://www.youtube.com/watch?v=PgKxze6RfhY	NFL|Ben Roethlisberger INJURY|MAJOR KNEE Sprained MCL INJURY; Leaves Game|Steelers versus Cowboys	Football
14	https://www.youtube.com/watch?v=tjJ3gd45tt8	Testis trauma and MCL injury	Soccer
15	https://www.youtube.com/watch?v=OHK-3Pu6kH0	Hall of meat! Skateboard fail! double heel flip- MCL injury	Skateboarding
16	https://www.youtube.com/watch?v=KcXjNNETC_c	MCL Tear	Backflip
17	https://www.youtube.com/watch?v=pm_tzaTK6js	Adrian Peterson was injured bad (sounds like he has a seizure) versus Redskins in 2011	Football
18	https://www.youtube.com/watch?v=EiyFB8×yOA0	David Johnson Suffers Gruesome Leg Injury Career-Ending Injury	Football
19	https://www.youtube.com/watch?v=4uFskU4t8Vs	Torn MCL playing Goalie	Ice Hockey
20	https://www.youtube.com/watch?v=Qu8A8pFIdzs	OLYMPIC ATHLETE TEARS MCL PLAYING BASKETBALL!!! (HARD TO WATCH!!!)	Basketball
21	https://www.youtube.com/watch?v=_Fal4bmNeg4	XGW Wrestling: Drizzle tears MCL in the knee with moonsault!	Wrestling
22**	https://www.youtube.com/watch?v=uUCX3teJRBM	Full Contact Hockey - MCL Tear	Ice Hockey

**There were 2 injury videos in this link

Table 2: Game activities at the time of injury and their distribution.

Activity	Number of Cases	%
Stop/Rotate	3	13.0
Landing	1	4.3
Collision	14	60.9
Fall down	5	21.7
Total	23	100

knee. In another goalie injury, the injury was sustained while the goalie was sliding his foot on the ice during the maneuver and the knee came to the valgus position. In the other two athletes, there was an injury after the opponent's direct contact with the knee during the fight for the puck.

Soccer

One athlete had a valgus strain on the knee while the hip fell in abduction after the indirect contact with his opponent. In the other two athletes, one was injured after direct contact with an opponent, while the other was running after the ball.

Others

In three of these injuries, the MCL sustained the injury as the first foot came in contact with the ground (wrestling and backflips). The skateboarding MCL injury occurred in the

Table 3: Distribution of body part positions and proportions according to video analysis.

Anatomical Part	Position	Position of Movement relative to Planes	Number of cases (n)	Distribution of Cases (%)
TRUNK	Trunk Position	Flexion	13	56.5
		Extension	10	43.5
	Trunk Tilt	Neutral	12	52.2
		Ipsilateral	10	43.5
		Contralateral	1	4.3
	Trunk Rotation	Neutral	10	43.5
		Ipsilateral	11	47.8
		Contralateral	2	8.7
HIP	Hip Position (Sagittal)	Neutral	1	4.3
		Flexion	21	91.3
		Extension	1	4.3
	Hip Position (Coronal)	Neutral	6	26.1
		Abduction	16	69.6
		Adduction	1	4.3
	Hip Rotation	Neutral	11	47.8
		Internal	7	30.4
		External	5	21.7
KNEE	Knee Position (Sagittal)	Flexion	21	91.3
		Extension	2	8.7
	Knee Position (Coronal)	Neutral	3	13.0
		Varus	1	4.3
		Valgus	19	82.6
ANKLE	Ankle Position (Sagittal)	Neutral	18	78.3
		Plantarflexion	2	8.7
		Dorsiflexion	3	13.0
	Ankle Position (Coronal)	Neutral	12	52.2
		Varus	0	0.0
		Valgus	11	47.8
FOOT	Foot Position	Neutral	14	60.9
		Supination	0	0.0
		Pronation	9	39.1
	Foot Rotation	Neutral	16	69.6
		External	6	26.1
		Internal	1	4.3

foot that was fixed to the ground when his other foot moved the skateboard. Finally, in the water-skiing injury, valgus strain occurred in the knee due to the impact of the water on the foot.

DISCUSSION

The important findings in this study were that MCL injury occurred when valgus force was applied when the trunk was flexed and turned toward the injured side, the hip was abducted and slightly flexed, and the knee was slightly flexed. In 69.6% of these cases, there was direct lateral contact to the knee. The most common injury occurred as a result of a collision with an opponent or an object.

Isolated MCL injuries are common ligament injuries of the knee and are generally treated conservatively.[4] However, injuries on the medial side are heterogeneous. The complex anatomy of this region has led to the difficulty of planning with a standard algorithm for treatment. Knowing the MCL anatomy makes it much easier to understand the clinical examination and pathological anatomy and to choose the correct treatment method to obtain a stable knee close to normal function and return to the pre-injury activity levels.[13] Injury prevention research has been described as a step-by-step process in which information about its causes is systematically collected and used to develop potentially effective intervention methods. It is important to identify the triggering event or mechanism of injury to develop specific injury prevention methods for a particular type of injury in a particular sport.[8] To know the mechanism of injury is necessary to effectively design specific exercise programs to reduce its frequency.[8,12] Video analysis in determining the injury mechanism may reveal deficiencies or mislead the mechanisms specified by the previously determined theoretical models.[10,11] Since the present study is the first video analysis study on MCL injury mechanisms in the literature, it provides valuable information.

The MCL is the main medial stabilizer against valgus stress in the knee and provides resistance against external rotational trauma of the lower extremity.[14,15] The information in the literature agrees that direct or indirect valgus stress applied to the flexed knee will play a role in MCL injury.[2,6,7,16-19] On the other hand, it is not clear whether the external rotation mechanism accompanies isolated MCL injury.[2,3,6,7,16-20] In the present study, the rate of external rotation of the tibia accompanying the injury mechanism was only 26.1% of the cases. Often the injuries were not accompanied by rotation.

One previous study examined the relationship between pronation-type ankle injuries and MCL injuries.[21] When pronation force is applied to the ankle and subtalar joint, internal rotation and abduction of the tibia occur together.[22] This event causes valgus and rotational force in the knee joint, which forces the medial-sided structure of the knee, causing valgus knee injury.[23] In the present study, the foot was in pronation in 39.1% of the cases. This situation was in the form of the foot taking the pronation position while the proximal tibia medialized with the valgus force applied directly to the knee while standing on the ground. Or, when the foot was suddenly placed on the floor while the hip was abducted, valgus strain occurred in the knee while the foot was going to pronation.

MCL injuries mostly occur by contact.[4,6,20] Lundblad *et al*. reported 70.4% of contact-related injuries.[6] A similar rate of injury occurring after contact was determined in the present study. And 88.9% of these were seen after direct contact with the knee from the lateral.

These injuries are common in contact sports such as football, ice hockey, rugby, wrestling, and judo.[6] Basketball and football were the most common injury groups in this study. And often, there was an injury due to a blow from an opponent during a double fight.

In the prevention of sports injuries, exercise programs, the use of a brace, regulation in sports rules, or the strict application of the rules against some positions by the referees can be counted.[5,6,24] Considering that the majority of MCL injuries occur by contact mechanism, the use of a brace and sports rules are more important in the prevention of injury. However, the use of a brace may reduce sports performance.[5] In this case, the sports rules and the strict enforcement of these rules by referees may be important in preventing MCL injury. New developments in brace technology may play a key role against these injuries in the future.

There are several shortcomings of the present study. Factors such as demographic characteristics, characteristics of MCL injury, treatment method, duration, and characteristics of rehabilitation are not known. In addition, the risk factors for these injuries to cause MCL injury is unknown. Furthermore, because injury data are derived from public records, they may not be 100% accurate and it may not be confirmable that every athlete assessed as an isolated MCL injury during the study period suffered an isolated MCL injury or was an isolated injury. However, video analysis of injuries reported on YouTube is an accepted method used to identify different injuries.[10,11] Another shortcoming can be listed as the limitations in video analysis. Since the videos are uploaded by different people and/or for different purposes, the video quality and camera angles, the distance the image was taken from, and the number of views obtained from different angles were not the same. At the same time, there were amateur camera shots as well as injuries to professional athletes. For this reason, some videos were examined from one angle. Due to the lack of this standardization, joint angles based on injury could not be measured on a video program and thus could not be analyzed quantitatively by pouring into numerical values. Since only the positions at the time of MCL injury were defined, they could be evaluated qualitatively. However, despite these deficiencies, valuable information regarding MCL injuries occurring during professional or amateur sportive activities can be gained as this is the first study to examine body positioning and activities of isolated MCL injuries through video analysis.

CONCLUSION

Isolated MCL injury occurs when valgus force is applied with the trunk flexed and turned towards the injured side, the hip abducted and slightly flexed, and the knee slightly flexed. The majority of these cases occur after a direct blow to the lateral knee.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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Conflicts of interest

There are no conflicts of interest.

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