SYSTEMATIC REVIEW

Management of Iatrogenic Medial Collateral Ligament Injury in Primary Total Knee Arthroplasty: A Systematic Review

Shayan Amiri, MD; Alireza Mirahmadi, MD; Ava Parvandi, MD; Pooya Hosseini-Monfared, MD; Reza Minaei Noshahr, MD; Seyyed Mehdi Hoseini, MD; Seyed Morteza Kazemi, MD

Research performed at Bone Joint and Related Tissues Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran

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Abstract

Objectives: The medial collateral ligament (MCL) injury is one of the possible complications of primary total knee arthroplasty (TKA), which can lead to coronal-plane instability that requires surgical revision. Injured MCL can result in joint instability and polyethylene wear. Different strategies have been proposed for MCL reconstruction based on the location of the injury. However, there is a lack of clarity regarding the optimal method for handling an iatrogenic MCL injury throughout a TKA.

Methods: A PRISMA flow diagram was used to guide the systematic literature review. An extensive search was conducted in PubMed, Embase, Scopus, Web of Science, and Google Scholar. Newcastle Ottawa scale checklist was used to assess the methodological quality of the articles.

Results: A total of 19 qualitative studies, including non-cadaveric patients with MCL injury during TKA, were identified after analyzing the full text of the articles. All included studies were either retrospective, observational cohort or case series. A total of 486 patients were studied to gather information on the methods used to repair the MCL and their results. Most injuries arose in the tibial attachment, which surgeons mostly realized during the final stages of surgery. Used techniques can be categorized into three main groups: Primary repair, Repair with augmentation, and changing prosthesis characteristics.

Conclusion: This systematic review demonstrated that the most popular management of iatrogenic MCL injury was using suture anchors, staples, screws and washers, and more constrained prostheses. The proper method should be decided considering the site of the MCL injury.

Level of evidence: I

Keywords: Arthroplasty, Iatrogenic mcl injury, Intraoperative complications, Intraoperative repair, Knee, Medial collateral ligament

Introduction

Iatrogenic injury of the medial collateral ligament (MCL) during primary total knee arthroplasty (TKA) can lead to coronal-plane instability, which may require revision TKA if left untreated.[1-5] The incidence of iatrogenic MCL injuries ranges from 0.77 to 2.7% in TKA patients (2.4), and it may reach 8% among obese patients.[5] An injured MCL can result in knee instability, which can accelerate the polyethylene wear. Additionally, a lack of MCL leads to pain and decreased postoperative function of the knee.[3,6,7]

Iatrogenic MCL injury occurs at various sites, such as mid-substance,[6] tibial insertion,[8,9] and femoral insertion.[10] There are two main categories of risk factors for iatrogenic MCL injury during TKA: patient-related factors and surgeon-related factors. The patient-related factors such as severe varus deformities, associated sagittal deformities such as fixed flexion deformities, knee stiffness, osteoporosis, and obesity are associated with an increased risk of MCL

Corresponding Author: Seyed Morteza Kazemi, Bone, Joint and Related Tissue Research Center, Akhtar Orthopedic Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran

Email: kazemimort@gmail.com

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injuries.[11] There are also surgeon-related factors such as hyper-flexing the knees during the exposure, failing to remove tenting medial osteophytes beneath the MCL, not protecting the MCL while handling the oscillating sawblade, incorrectly balanced MCLs, insertion of thick trial meniscus components, retraction in hyperflexion, and forceful extension increase the risk of intraoperative MCL injury.[4,12]

There is still ongoing debate surrounding the most effective approach for handling intraoperative MCL injury. The treatment options could be categorized into three main groups ranging from 1) primary repair, including using suture or staple only,[2,13,14] fixing with screws and washer construct,[13] or using suture anchors,[12] 2) repair with augmentation using autograft[6] or synthetic ligament,[15] or meniscus transfer,[16] 3) changing prosthesis characteristic such as thicker polyethylene insert,[12,17] or conversion to the constrained prosthesis.[3,12] Although various approaches exist for managing iatrogenic MCL injuries in TKA, there is still no agreement on the best approach when it comes to the site of injury. As such, this study aimed to assess all possible techniques that can be utilized in this context.

Materials and Methods

In accordance with PRISMA (18), articles were screened against eligibility criteria prior to performing the systematic review. In this study, the researchers identified patients who experienced an intraoperative iatrogenic MCL injury while undergoing primary TKA using data obtained from the existing literature. During these primary TKA, the MCL was injured intraoperatively as an inadvertent intraoperative event. Observational studies were considered retrospectively and prospectively since randomized trials were not anticipated. To find non-cadaveric original articles across a wide range of databases without limiting language, a search strategy was developed. An assessment of the quality scores of included studies was done using the Newcastle-Ottawa Scale.

Search Strategy

The following keywords were used during the period from conception to March 2023 by an independent investigator (AM) to search PubMed, Embase, Scopus, Web of Science, and Google Scholar: ("knee arthroplasty" OR "knee replacement" OR "TKA") AND ("MCL" OR "medial collateral ligament" OR "collateral ligament") as well as MeSH terms.

Eligibility and Study Selection

We included all studies investigating the iatrogenic MCL injury during TKA in any language. Exclusion criteria were 1) case reports, 2) reviews (narrative, systematic, or meta-analyses), 3) cadaveric studies, 4) animal studies, 5) consensus statements and guidelines, 6) editorial notes, letters, and conference abstracts, 7) studies with insufficient data. Two independent authors (AP and SA) reviewed every report.

Results

The flowchart for this systematic review can be found in [Figure 1]. We used PubMed, Scopus, Embase, Web of Science, and Google Scholar in the initial search. A total of 2,132 articles were found during the initial search, including 381 articles from PubMed, 820 from Scopus, 427 from Embase, 382 from Web of Science, and 122 from Google Scholar. A total of 1,145 articles were removed by Endnote software as duplicate articles. Due to inappropriate study types and inappropriate study participants, 927 out of 987 reports were excluded as a result of the title and abstract screening and application of the exclusion criteria. Upon evaluating the full text of the studies, 19 qualitative studies were identified. A summary of the study and patients' characteristics is shown in [Table 1]. An evaluation was conducted on 19 retrospective studies, including 486 patients. [Table 2] contains more details about the information that we went over and selected from the articles. Iatrogenic MCL injuries occur at three sites: tibial insertion, femoral insertion, and mid-substance. As shown in [Table 3], in most studies, most injuries arise in the tibial attachment, which surgeons may realize during the final stages of surgery. The most popular techniques were primary repair and augmentation, suture anchors, staples, screws and washers, and more constrained prostheses.

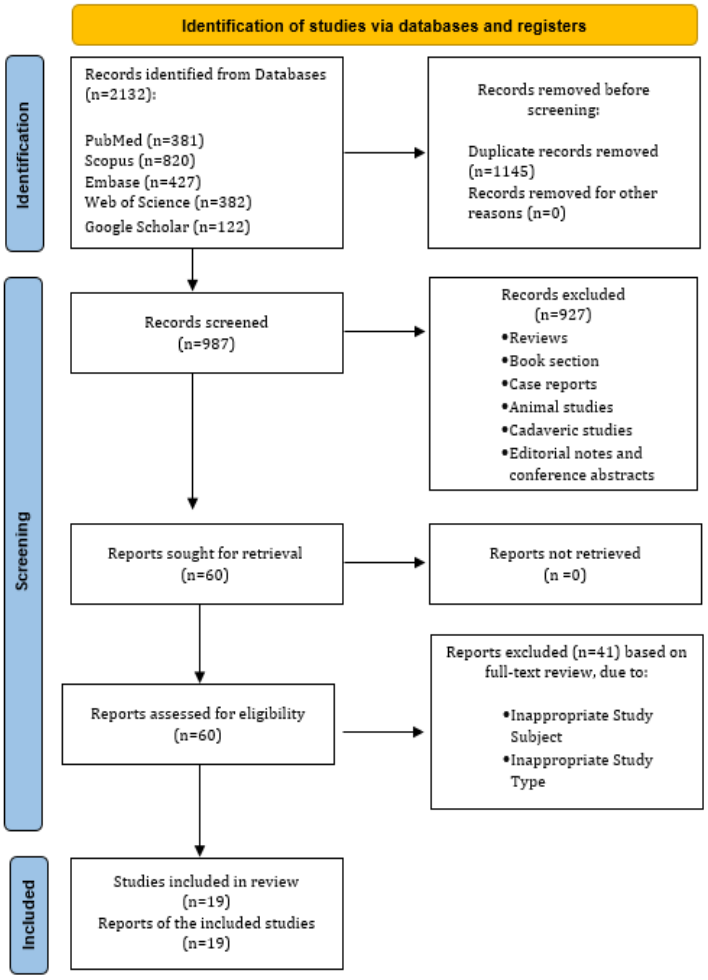

Figure 1. Study selection based on the Preferred Reporting Items for Systematic Reviews (PRISMA) 2018 statement

Table 1. Characteristics of the included studies

Lead Author	Year	Country	Study Period	Study Design, Patient Enrollment	No. of Cases	Follow-up Period (months)	Age (y),Mean or Range	Male/Female, %
Jin et al.[9]	2022	China	January 2003 to December 2015	Prospective, consecutive	43	24	67 (59–74)	4/96
Liu et al.[21]	2021	China	January 2016 to 2018	Prospective, consecutive	14	24	67.3±6.6	14.28/85.75
Li et al.[22]	2021	China	January 2009 to December 2016	Prospective, consecutive	14	24	72.6±3.9	21.42/78.58
Sun et al.[16]	2020	China	January 2014 to November 2019	Prospective, consecutive	11	24	64.2 ± 5.64	18/82
Rajkumar et al.[10]	2020	India	January 2011 to December 2015	Prospective, consecutive	41	24	65.22 ± 7.97	17.1/82.9
Motiffard et al.[23]	2020	Iran	2007 to 2017	Prospective, consecutive	35	24	68±5	5.6/94.4
Ni et al.[25]	2020	China	March 2018 and March 2019	Prospective, consecutive	14	15.6	63.6 (49–79)	14.28/85.75
White et al.[20]	2019	USA	2005 to 2015	Prospective, consecutive	33	24	63.6 (8.95)	30.3/69.7
Jin et al.[24]	2019	South Korea	January 2003 to June 2014	Prospective, consecutive	65	24	71.4±7.8	NA
Choi et al.[8]	2018	South Korea	January 2001 to February 2006	Prospective, consecutive	53	24	67.4 ± 6.0	0/100
Wang et al.[26]	2017	China	2007 to 2013	Prospective, consecutive	17	24	63.0±4.2	23.52/76.48
Siqueira et al.[4]	2016	USA	January 2003 and December 2009	Prospective, consecutive	23	24	66.5 ± 9.7	13/87
Cao et al.[27]	2016	China	March 2009 to May 2014	Prospective, consecutive	11	24	64.3 (55-77)	18.18/81.82
Bohl et al.[13]	2016	USA	1991 to 2009	Prospective, consecutive	45	24	85.22	15.55/84.45
Shahi et al.[15]	2014	USA	January 2003 and November 2012 a	Prospective, consecutive	11	12 ± 5	64 (43-85)	NA
Dragosloveanu et al.[12]	2013	Romania	2005 to 2012	Prospective, consecutive	10	12	64.8	NA
Stephens et al.[14]	2012	USA	5 years	NA	9	NA	58	NA
Lee et al.[3]	2010	USA	1998 to 2004	Prospective, consecutive	37	24	60	48.64/51.36
Leopold et al.[2]	2001	USA	June 1991 to June 1997	Prospective, consecutive	14	45	63 (47-86)	28.57/71.43

Table 2. Newcastle-Ottawa scale of the included studies

	Selection	Comparability	Exposure	Total
Sun et al.[16]	★★★	★★	★★	7
Jin et al.[9]	★★★	★★	★★	7
Rajkumar et al.[10]	★★★	★★	★★	7
Motiffard et al.[23]	★★★	★★	★★	7
Liu et al.[21]	★★★	★★	★★	7
Li et al.[22]	★★★	★★	★★	7
Ni et al.[25]	★★★	★★	★★	7
White et al.[20]	★★★	★★	★★	7
Jin et al.[24]	★★★	★★	★★	7
Choi et al.[8]	★★★	★★	★★	7
Wang et al.[26]	★★★	★★	★★	7
Siqueira et al.[4]	★★★	★★	★★	7
Cao et al.[27]	★★★	★★	★★	7
Bohl et al.[13]	★★★	★★	★★	7
Shahi et al.[15]	★★★	★★	★★	7
Dragosloveanu et al.[12]	★★★	★★	★★	7
Stephens et al.[14]	★★★	★★	★★	7
Lee et al.[3]	★★★	★★	★★	7
Leopold et al.[2]	★★★	★	★★	6

Table 3. Details of the included studies

Lead author	Year	Method of repair	No. of patients	Site of injury	Phase of injury	KSS**	KSF***	No. of revisions
Jin[9]	2022	Suture anchor	43	tibial attachment	final stage of surgery	NA*	86_3 ± 8.1	0
Liu[21]	2021	Suture anchor	14	tibial attachment	final stage of surgery	87.6 ± 2.7	NA*	1
Li	2021	Suture anchor	14	9 mid-substance 5 femoral attachment	NA*	93.3±4.7	NA*	NA*
Sum.[16]	2020	Aaugmentation of medial meniscus transfer_	11	tibial attachment	final stage of surgery	95 ± 4.47	91.8± 7.5	0
Rajkumar[10]	2020	Screw and washer construct	41	femoral attachment	final stage of surgery	80 to 90	80 to 95	0
Motiffard[23]	2020	Suture	35	mid-substance	trial reduction or in the final stages of surgery	81 ± 17	61 ± 13	3
Ni[25]	2020	Screw and rectangular spiked washer	14	femoral attachment	final stage of surgery	NA*	NA*	0
White[20]	2019	Staple	33	tibial attachment	NA*	NA*	NA*	0

Table 3. Continued

Jin (a)[24]	2019	Suture anchor	36	tibial attachment	final stage of surgery	86.4 ± 7.2	NA*	0
Jin(b)[24]	2019	Staple	29	tibial attachment	final stage of surgery	88.3 ± 7.5	NA*	0
Choi[8]	2017	Suture anchor	40	tibial attachment	final stage of surgery	23.3 to 92.7	69.9± 8.4	3
Wang[26]	2017	MCL reconstruction without a constrained	17	12 mid-substance, 5 femoral attachment	final stage of surgery	NA*	84.7± 5.9	0
Siqueira[4]	2016	Unconstrained with repair	10	NA*	NA*	79.2 ± 21.6	78.1 ± 22	0
Siqueira[4]	2016	Constrained with repair	3	NA*	NA*	50 ± 36	51.7 ± 20.8	0
Siqueira[4]	2016	Constrained	8	NA*	NA*	91.1 ± 10.5	59.3 ± 20.3	0
Cao[27]	2016	Semitendinosus and gracilis tendon	11	tibial attachment	final stage of surgery	89.82 ± 3.76	89.54 ± 3.50	0
Bohl[13]	2016	Femur avulsion was repaired using suture with a screw-and-washer construct of the avulsions tibia avulsion, 4 with suture alone, 9 with suture anchors, and 7 with suture with a screw-and-washer construct A cruciate-retaining prosthesis was used in 35 total knee arthroplasties, and a posterior stabilized prosthesis was used in 10	45	24 mid-substance, 20 tibial attachment 1 femoral attachment	final stage of surgery	NA*	NA*	5
Shahi[15]	2014	Synthetic ligament	11	tibial attachment	final stage of surgery	76to 100	NA*	0
Dragoslovean u[12]	2013	7 suture anchor 3 constrained tibial	10	7 mid-substance 3 tibial attachment	final stage of surgery	87.71	NA*	1
Stephens[14]	2012	Primary repair	9	mid-substance	NA*	NA*	73.3	0
Lee[3]	2010	Increased constraint	37	28 mid-substance, 9 tibial attachment	final stage of surgery	NA*	83	3
Leopold[2]	2001	Primary repair	14	mid-substance	NA*	93	NA*	0

*Not applicable, **Knee Society Score (KSS), ***Knee Functional Score (KFS)

Discussion

Injury to MCL during TKA is often unrecognized and rarely discussed. Due to its iatrogenic nature, prospective controlled studies were not found in the search. Based on the included studies site of injury and phase of detection could be possible influential factors for choosing the best repair techniques. Although sex, age, body mass index, and being a professional athlete may be influential factors, they were not

mentioned in studies. Knee instability, accelerated wear, loosening, and revision surgery may result from unrecognized MCL injury.[18,19]

1) Primary Repair:

Mid-substance disruption of the MCL can be treated with primary repair and postoperative bracing.[2]

a. Staple or Suture Only

A study conducted by White et al.[20] found that using staples to repair iatrogenic MCL injuries in tibial insertion had better functional outcomes and satisfaction compared to those who underwent revision TKA for instability and those who underwent TKA without MCl injury. However, 19.2% of patients with the staple repair were found to have instability.

b. Suture Anchor

For repairing iatrogenic injuries, Jin et al.[9], Liu et al.[21], Li et al.[22] and Motififard et al.[23] used suture anchors. The study conducted by Jin et al. involved an injury to the tibial attachment site, whereas Motififard's involved an injury to the mid-substance. As reported in the study by Jin et al., the results after two years of follow-up in the injury group were similar to those in the control group without iatrogenic injury of MCL.

In the study carried out by Motififard et al., however, results were not satisfactory, and 15% of the repairing group had instability. Choi et al. also reported an identical survival rate for the patient and control groups after 13 years.[8]

Nevertheless, in the research by Jin et al. (2019)[24] which the suture anchor and staple groups were compared in MCL injury at tibial insertion, no difference was observed regarding the Western Ontario and McMaster Universities Arthritis Index (WOMAC) and Knee Society Score (KSS). Furthermore, no statistically significant difference in stability was found between the suture anchor and staple groups.

C) Screw and Washer

In studies by Ni et al.[25] and Rajkumar et al.,[10] it was demonstrated that femoral bony MCL avulsions during TKA could be repaired using screw and washer constructs. As a result, the excellent clinical and radiological outcomes achieved through this approach obviated the necessity for augmenting constraints. One or two K-wires were used to hold the avulsed fragment and attach the MCL in place. Depending on the fragment size, a cancellous screw with a washer of 3.5 mm was inserted when the knee was in 30 degrees of flexion.

2) Augmentation with Autograft

a. Autograft (Semitendinosus or Gracilis)

An augmentation with autograft of the semitendinosus tendon was used in the study by Wang et al.[26] for primary double-bundle MCL reconstruction without constrained components. In 12 cases, the MCL injury was midsection, while in five cases, it was avulsed from the femur metaphysis. The authors demonstrated that TKA without a constrained implant produces excellent results when repairing MCL injuries. In the study by Cao et al.,[27] which used both semitendinosus and gracilis tendon in MCL injuries at the joint level, the same result was shown. According to their latest follow-up, both groups had comparable KSS and functional scores.

b. Synthetic Grafts

The mid-substance MCL injuries in the study by Shahi et al.[15] occurred due to direct injury from either an oscillating saw blade or sharp instruments used for medial subperiosteal lifting. The MCL was exposed during the procedure, and a synthetic ligament (NeoligamentsTM, Xiros Company, Leeds, UK) was utilized. This synthetic ligament is constructed with parallel longitudinal polyester fibers, forming an open mesh scaffold structure that facilitates tissue growth. To secure the synthetic ligament to the tibia, nonabsorbable sutures were employed to suture the graft onto the medial aspect, commencing proximally from the medial epicondyle. Additionally, the femoral and tibial attachments were sutured using deep interrupted sutures to the periosteum.

c. Meniscus Transfer

A medial meniscus transfer is another effective method. In the study by Sun,[16] this method was used for the first time for iatrogenic MCL injury in tibial attachment, and it showed excellent results in clinical outcomes of the injury group and the KSS and knee functional score (KSF).

3) Changing Prosthesis Characteristics

a. Thicker Polyethylene

During the study by Koo,[17] thicker polyethylene was inserted to achieve balance and stability in the mediolateral soft tissue at 0°, 30°, and 90° of knee flexion following the detection of the intraoperative MCL injury from the tibial attachment site. It was generally recommended to use a 2-mm to 4-mm thicker polyethylene insert compared to the initial one to stabilize the knee joint and allow some degree of lateral tightness. Standing anteroposterior radiography showed almost 4° more valgus in the tibiofemoral angle in the MCL-off knees than the MCL-intact side. However, there were no complaints of knee instability in daily activities.

b. Conversion to the Constrained Prosthesis

Conversion into constrained prostheses is the most popular strategy. As this method was used in a study performed by Lee,[3] patients with increased constraint (TCIII; DePuy) had similar scores to those without ligament injuries during TKA. Among the MCL disruptions observed, 28 cases were characterized by transection of the ligament, while nine cases involved avulsion of the collateral ligament from the tibial metaphysis. Four patients were revised for instability among the seven who did not receive more constrained prostheses.

Otherwise, in a study conducted by Siqueira,[4] treatment of the MCL injury was determined by the surgeon and consisted of using an unconstrained implant with (n=10) or without (n=2) primary ligament repair, a constrained implant with (n=3) or without (n=8) ligament repair. One patient had an avulsion from the tibial metaphysis, while the other 22 patients had mid-substance injuries. Baseline KSS varied among the four treatment groups, but postoperative KSS

scores showed no significant differences. Preoperative and postoperative KFS did not differ among the treatment groups. The difference between preoperative and postoperative KSS scores was significant, but not for KFS scores. When comparing preoperative KSS scores and the difference between pre-and postoperative KSS scores, pairwise comparisons between the groups revealed no statistically significant differences.

The mentioned techniques demonstrated various outcomes in different studies. These variations could be due to different patient demographics, surgeons, and follow-up methods. However, one of the main determinants was the site of injury. As mentioned, most of the studies evaluate MCL avulsion from tibial insertion. Primary repairs, staples, suture anchors, augmentation with autograft, and changing prosthesis characteristics were used for these patients. In contrast to tibial insertion injuries, fewer studies reported femoral insertion injuries, but the Screw and washer technique has shown a proper outcome for these patients. In addition, primary repair and augmentation with autografts are preferred in mid-substance injuries.

Conclusion

Suture anchors, staples, screws and washers, and more constrained prostheses were the most common techniques of iatrogenic MCL injury management reported in the literature. However, the decision over the optimal strategy to manage the MCL injury during TKA should be made considering the site of the MCL injury.

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Shayan Amiri MD [1]
Alireza Mirahmadi MD [2]
Ava Parvandi MD [2]
Pooya Hosseini-Monfared MD [2]
Reza Minaei Noshahr MD [2]
Seyyed Mehdi Hoseini MD [2]
Seyed Morteza Kazemi MD [2]

1 Shohadaye Haftom-e-Tir Hospital, school of medicine, Iran University of Medical Sciences, Tehran, Iran

2 Bone, Joint and Related Tissue Research Center, Akhtar Orthopedic Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran

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