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Research Article

Surgical Technique of Medial Collateral Ligament Repair of the Knee with Bioinductive Membrane Augmentation

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Abstract

Introduction: The medial collateral ligament (MCL), a primary stabilizer against valgus forces, often requires surgical intervention in severe injuries, especially when associated with anterior cruciate ligament (ACL) tears. However, MCL repair or reconstruction is typically reserved for patients who continue to experience persistent valgus instability after nonoperative management has failed. The use of synthetic and biological implants is increasingly popular to augment these procedures, providing both biomechanical reinforcement and promoting natural healing. BioBrace, a biocomposite of collagen and bioabsorbable microfilaments, provides structural support and enhances tissue healing. This article explores the surgical treatment of high-grade medial collateral ligament (MCL) injuries of the knee using BioBrace augmentation through a case series.

Methods: Cohort of patients who underwent MCL repair surgery with a bioinductive membrane augmentation (BioBrace) between December 2023 and February 2024. This article presents surgical techniques, indications, and clinical outcomes from a case series, highlighting the benefits of BioBrace augmentation in improving stability and functional recovery.

Results: A total of 4 patients underwent MCL repair surgery with BioBrace. Results show that patients experienced reduced instability, faster rehabilitation, and favorable outcomes without significant postoperative complications.

Conclusion: This method offers a promising alternative for patients with complex knee injuries, especially athletes, by facilitating early rehabilitation and improving joint stability. Further research is recommended to evaluate long-term efficacy and optimize the surgical approach.

More Information

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Keywords: Medial collateral ligament; Augmentation; Knee injury; Anterior cruciate ligament

Introduction

The medial collateral ligament (MCL) is the primary stabilizer of the knee against valgus forces and also serves as a secondary restraint in external rotation across the entire range of motion [1]. MCL injuries are the most common among knee ligaments, with conservative treatment showing satisfactory functional results in most grade I and II injuries [2]. However, prognosis is less predictable in grade III injuries, where conservative treatment can result in residual instability affecting joint function in the long term [1].

Recent studies, such as those from the Swedish National Registry, suggest that a concomitant MCL and anterior cruciate ligament (ACL) injury significantly increases the risk of ACL re-rupture if the MCL injury is not surgically treated [3]. Consequently, surgical treatment is recommended for patients with grade III valgus instability, poor healing capacity, or complex injuries (Diagram 1) [4,5].

In recent years, there has been growing interest in using bioinductive and synthetic implants as adjuncts in the surgical treatment of the MCL to enhance repair or

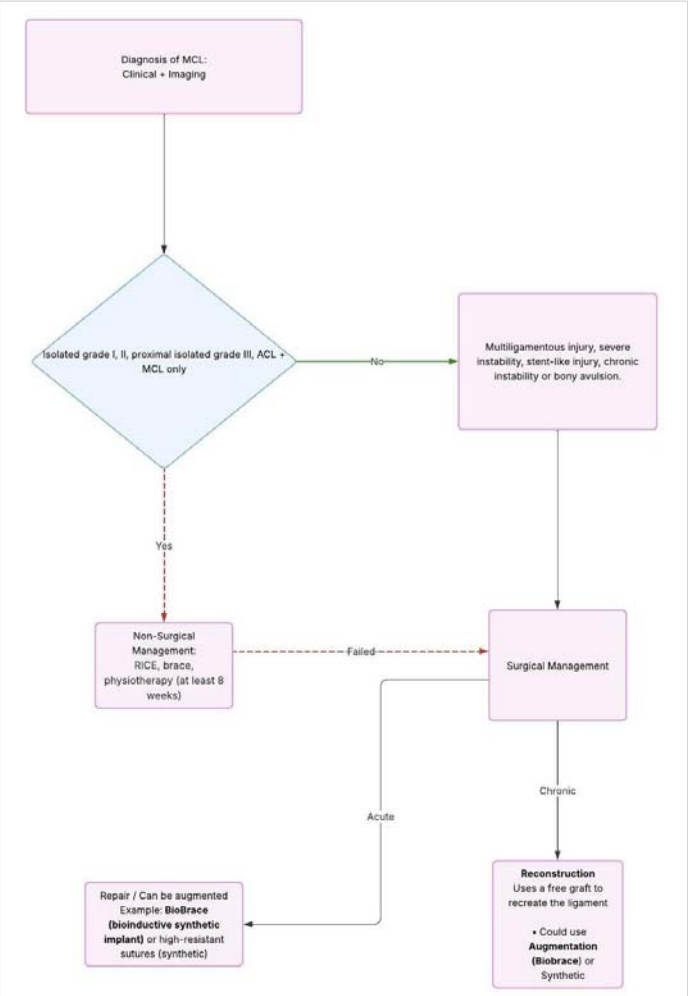

Diagram 1: MCL injury management flowchart.

reconstruction, improve healing, and provide biomechanical resistance [6]. This approach promotes a faster recovery by facilitating natural healing and load distribution in the repair, especially in the early postoperative period [7,8]. The BioBrace (ConMed), a biocomposite of type I collagen and bioabsorbable polylactide (PLLA) microfilaments, represents an advancement in this regard, offering a structure that supports tissue regeneration and provides mechanical resistance for up to two years, facilitating complete healing [9].

In this article, we describe the surgical technique and indications for using BioBrace in MCL repair and present a series of clinical cases documenting the application of this technique.

Methods

A retrospective cohort study was conducted at our center, Clinica Alemana Santiago, which included patients who underwent MCL repair surgery with a bioinductive membrane augmentation (BioBrace). Ethical review was undertaken by the Health and Disability Ethics Committee of our Center. Informed consent was taken from all patients for the use of data. No funding was required for this study.

Patients followed the standard rehabilitation protocol at our center. Excluded from the study were those with neurovascular injuries, tibial plateau fractures, or procedures combined with osteotomy.

All surgeries were performed by experienced knee surgeons (10+ years of experience), under general anesthesia with a thigh-high tourniquet. Patients typically stayed one night in the hospital and completed at least one physiotherapy session before discharge.

Indications for surgery

There is an ongoing debate about the treatment of high-grade MCL injuries when associated with ACL rupture [10]. However, specific indications for MCL repair or reconstruction with augmentation have been identified in the following cases [5,11]:

- Multiligamentous injury involving the MCL along with the central pivot (ACL and posterior cruciate ligament, PCL).
- MCL injury associated with an ACL tear in high-performance athletes presenting valgus laxity in extension.
- Isolated chronic grade III MCL injury with persistent laxity and instability symptoms.
- Stener-type injuries with pes anserinus interposition that impedes natural healing.

Patient study

Proper preoperative planning requires a comprehensive physical examination of the patient, including tests for anteroposterior stability (Lachman, anterior drawer, and posterior drawer tests), Pivot Shift and Dial tests, and varus and valgus stability tests at 0° and 30° flexion [12]. In addition to physical examination, imaging studies should include standard radiographs (anteroposterior, lateral, and Rosenberg) and full-leg radiographs to assess axial alignment [6]. Stress radiographs are also recommended to provide an objective measure for surgical diagnosis and follow-up [6]. Magnetic resonance image (MRI), the gold standard for knee ligament injuries, is essential to determine the type and specific location of the MCL injury and identify any additional medial stabilizer injuries [11].

Surgical technique

Patient positioning may vary depending on the surgeon's preference. Our team prefers placing the patient supine on an operating table that allows independent flexion of the operative leg, using a tourniquet to achieve ischemia in the area. Anesthesia is followed by examination for anteroposterior stability and valgus at 0° and 30° flexion [13]. The operative leg is draped with a knee arthroscopy-specific sterile field and positioned at 30° flexion.

A longitudinal anteromedial incision is made along the superficial MCL. For a minimally invasive approach, a smaller incision at the medial epicondyle and another at the distal insertion of the superficial MCL can be chosen (Figure 1). The sartorial fascia is dissected, and the pes anserinus tendons are retracted posteriorly to expose the superficial MCL, taking care to avoid injury to the saphenous nerve [13].

The insertion of the superficial MCL is approximately 3.2 mm proximal and 4.8 mm posterior to the medial epicondyle (Figure 2), and the distal MCL insertion site can be found 6 cm from the joint line on the posterior 1/3 of the tibia (Figure 3) [14]. To secure the BioBrace, a suture anchor is placed just proximal and posterior to the medial epicondyle (Figure 4, left), enabling anatomical repair and advancement of the MCL. The ligament is repaired with a horizontal mattress suture pattern with the knee at 30° flexion while applying varus tension [7].

The distal end of the BioBrace is temporarily held in place with a fixation suture or Kocher clamp for tension application. An anchor is then placed approximately 6 cm distal to the joint line (Figure 4, right) to secure the BioBrace in its final position with the knee at 30° flexion and a varus moment [6]. Any excess BioBrace is trimmed, and additional sutures are added to secure its length to the deep MCL and the underlying joint capsule. Before closing, the knee is assessed to verify the absence of valgus instability at 0° and 30° flexion. Finally, the sartorial fascia is repaired with absorbable sutures, and a layered closure of the skin is performed [15].

Surgical Tips for MCL Repair or Reconstruction with BioBrace

- Tension the repair or reconstruction and BioBrace with the knee in 30° flexion, applying varus stress to prevent residual laxity.
- Place the BioBrace as close as possible to the MCL's isometric point to minimize postoperative laxity.
- Soak the BioBrace in the patient's blood to facilitate handling and improve integration with tissues.
- Use tapered or cutting needles to pass sutures through the BioBrace, allowing easy manipulation without compromising its integrity.

Postoperative rehabilitation

After surgery, the patient is immobilized with an adjustable range-of-motion brace, limiting flexion to 30° during the first two weeks. From this point onward, full range of motion is permitted with a brace that provides coronal plane control. Partial weight-bearing is initiated in the first four weeks, progressing to full weight-bearing with the brace [7]. This brace is removed between six and eight weeks postoperatively, at which point the patient can begin specific strengthening exercises and load adjustments based on clinical tolerance [15].

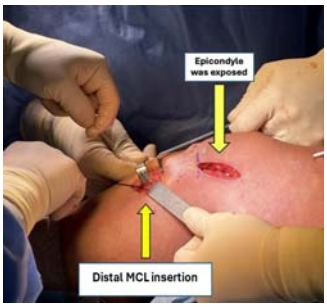

Figure 1: Minimally invasive approach, centered at the medial epicondyle and the distal insertion of the superficial MCL.

Figure 2: Femoral MCL anatomical insertion site proximal and posterior to the medial epicondyle, identified with a K-wire.

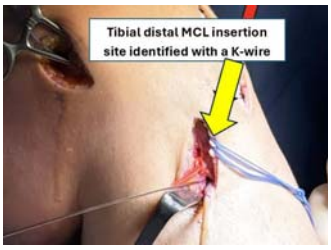

Figure 3: The tibial MCL anatomical insertion site is 6 cm from the joint line on the posterior 1/3 of the tibia, identified with a K-wire.

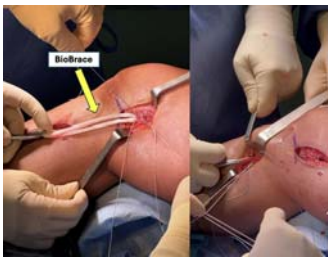

Figure 4: Left – An anchor is placed just proximal and posterior to the medial epicondyle to secure the BioBrace. Right - An anchor is then placed approximately 6 cm distal to the joint line to secure the BioBrace in its final position.

Case reports

Case 1

A 48-year-old patient with a medical history of hypertension and previously treated thyroid cancer sustained an acute traumatic injury to the right knee during a volleyball match following a valgus mechanism. Clinical

examination revealed mild effusion, full range of flexion and extension, anterior-posterior instability, and valgus laxity at 30° of flexion. MRI demonstrated a complete ACL rupture, combined proximal and distal medial collateral ligament tears, and a longitudinal tear of the lateral meniscus in the posterior horn. The patient underwent ACL reconstruction with allograft and MCL augmentation using a BioBrace scaffold.

The patient progressed with an increase in joint range from 0-60 to 0-90 between the 3rd and 4th week, with decreased effusion, pain, and instability.

Three months postoperatively, was in improved condition, with a ROM of 0-110, no referred pain, and good anteroposterior and medial stability. A follow-up MRI at six months confirmed an intact ACL reconstruction and evidence of progressive healing of the MCL repair (Figure 5). Finally, at 8 months of follow-up, the patient responded well to rehabilitation, with a ROM of 0 - 130 and good medial, lateral, and anteroposterior stability.

Case 2

A 41-year-old otherwise healthy patient sustained a left tibial plateau fracture and a right multiligamentous knee injury following a motorcycle accident. After managing the tibial plateau fracture, the patient underwent surgical intervention on the right knee three months later. Physical examination revealed medial instability in extension, lateral instability with a positive dial test, valgus laxity, and anterior-posterior instability. MRI identified injuries to the ACL, posterolateral corner (including the lateral collateral ligament and popliteal tendon), distal MCL avulsion, and multiple meniscal tears. Surgical treatment included ACL reconstruction, posterolateral corner repair using the Arciero technique, percutaneous MCL augmentation with BioBrace, and meniscal repair.

One month postoperatively, the patient showed a good clinical response with decreased pain and edema. Regarding functional progress, a ROM of 0-80 was evaluated. At 2 months, the patient presented with iliotibial band pain and a ROM of 0-90 with adequate medial-lateral and anteroposterior stability. A follow-up MRI at 6 months revealed continuous plasty with lateral meniscal suture without complications. A clinical examination was performed with a ROM of 0-115, and no changes in stability (Figure 6).

Case 3

A 49-year-old patient with no relevant past medical history sustained a right knee injury while skiing. The injury mechanism involved rotational forces, resulting in moderate effusion and clinical signs of anterior-posterior and valgus instability. MRI revealed a complete ACL rupture, a proximal third MCL tear, and a longitudinal posterior horn tear of the lateral meniscus. Surgical management included ACL

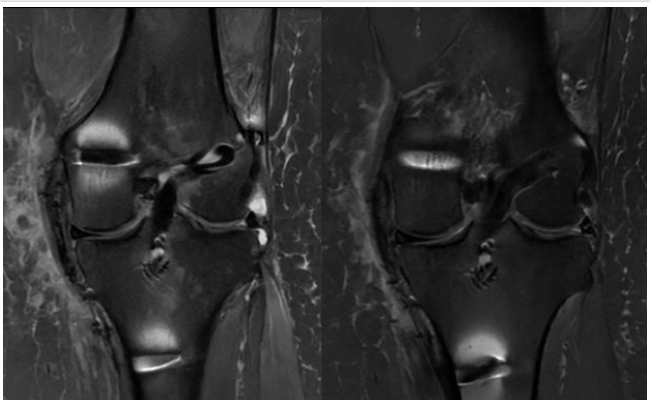

Figure 5: MRI at 6 months (left) and 9 months (right) postoperatively for Case 1.

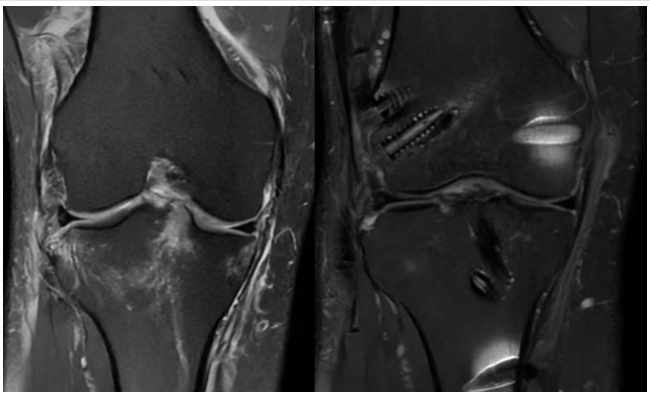

Figure 6: Preoperative (left) and 6 months postoperative (right) MRI of Case 2.

reconstruction using an allograft, MCL repair with BioBrace augmentation, and meniscal repair.

A follow-up at one month showed limited ROM between 0-50 with decreased effusion and good stability. Physical therapy in water was indicated, and the patient achieved a progressive increase in ROM to 0-60 at 2 months, allowing him to perform activities with low functional demands. With the initiation of intensive physical therapy and aquatic rehabilitation, knee function improved to 0–100° by four months, with maintained joint stability.

Case 4

A 17-year-old previously healthy patient presented with a right knee injury sustained during a soccer match following a torsional mechanism. Clinical examination demonstrated anterior-posterior and valgus laxity both in full extension and at 30° of flexion. MRI revealed a complete ACL rupture, Segond fracture, radial tear of the lateral meniscus, and distal MCL avulsion. Surgical treatment consisted of ACL reconstruction using the bone-patellar tendon-bone (BTB) technique, anterolateral ligament (ALL) reconstruction, lateral meniscus repair, and MCL repair augmented with BioBrace.

The patient presented with a one-month follow-up,

initially with limited ROM from 0-30, with improved stability and decreased joint effusion. The patient's control improved at 2 months, with a ROM of 0-90, with medial and anteroposterior stability. At 3 months, the ROM improved from 0-100 with continued stability, maintaining the same ranges at 4 months. At 6 months, the ROM was 0-120°, stability was maintained, and the MRI showed no signs of re-rupture and satisfactory graft maturation and healing (Figure 7).

Results

A total of 4 patients underwent MCL repair surgery with a bioinductive membrane augmentation (BioBrace) between December 2023 and February 2024. All patients were contacted in February 2025 for a follow-up review.

Most patients were men (75%), with a median age of 38.75 years (IQR: 17 - 49) and median body mass index (BMI) of 24.2 (IQR: 22.6 - 26.4).

Functional outcomes

The functional outcomes at 6 months postoperatively are detailed in Table 1.

No complications occurred during surgery. At the latest follow-up (1 year), none of the knees had undergone revision or were being considered for another surgery.

Table 1: Functional results measured on the IKDC, Tegner, and Lysholm scales, preoperatively and postoperatively, of the 4 cases presented.

Case Reports	Pre-op Results	Post-op Results
Case 1	•IKDC: 38 •Tegner:3 •Lysholm: 45	•IKDC: 72 •Tegner: 5 •Lysholm: 90
Case 2	•IKDC: 34 •Tegner: 2 •Lysholm: 40	•IKDC: 70 •Tegner: 5 •Lysholm: 85
Case 3	•IKDC: 36 •Tegner: 2 •Lysholm: 42	•IKDC: 65 •Tegner:4 •Lysholm: 80
Case 4	•IKDC: 40 •Tegner: 3 •Lysholm: 50	•IKDC: 78 •Tegner: 6 •Lysholm: 88

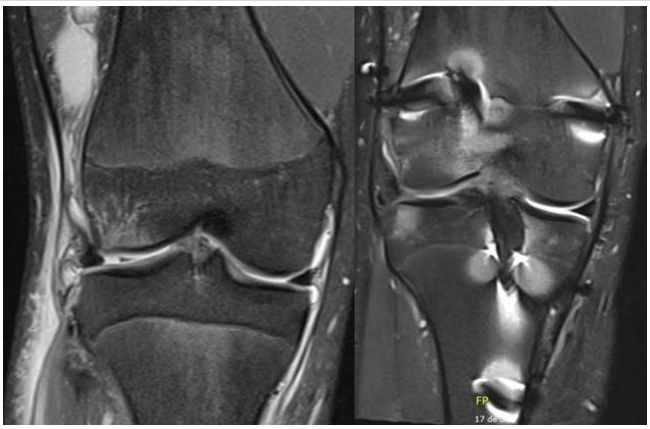

Figure 7: Preoperative (left) and 6 months postoperative (right) MRI of Case 4.

Discussion

MCL repair or reconstruction with bioinductive implant augmentation represents a significant advancement in the treatment of knee ligament injuries, especially in complex or grade III injuries. While non-surgical management of low-grade MCL injuries is well-documented [1-3], surgical intervention is preferred in cases of persistent instability or combined injuries to reduce the risk of chronic instability and improve functional outcomes [11,12,16,17].

The BioBrace augmentation technique is especially promising due to its bioinductive properties, which facilitate healing without the drawbacks of permanent synthetic implants, such as chronic inflammatory reactions or postoperative stiffness [9,13]. Animal studies have demonstrated its ability to promote organized connective tissue formation, a process that may be crucial for MCL functional recovery [8,14,17]. Furthermore, recent research indicates that augmentation with sutures or bioinductive devices like BioBrace enables early rehabilitation without compromising joint stability [7,13].

Using BioBrace as an adjunct in MCL reconstruction is especially beneficial in multiligamentous injuries or in patients with high functional demands, such as athletes [6]. These patients require solid stability for pivoting and cutting movements, and valgus instability can severely affect athletic performance [16].

In our case series, patients treated with BioBrace augmentation experienced rapid recovery, reduced instability, and no postoperative joint stiffness. These findings align with LeVasseur, et al. [9], who suggest that bioinductive scaffolds offer additional support that facilitates early rehabilitation and reduces long-term complication risks. Anatomical restoration and BioBrace placement near the isometric point have proven essential in preventing residual laxity [19].

While initial results are encouraging, long-term follow-up and prospective studies are necessary to evaluate the BioBrace's long-term effectiveness in MCL reconstruction, as well as its impact on revision rates and optimal medial stability.

Conclusion

MCL reconstruction with BioBrace represents a significant advancement in the treatment of complex knee injuries, offering a combination of mechanical support and healing facilitation that enhances functional outcomes in patients with high valgus stability and rotational resistance demands.

Compliance with ethical standards

Investigation was performed at Clinica Alemana de Santiago, Vitacura, Chile.

Evidence level: IV

Authors' contribution: J.A., D.F., and W.G. contributed to the conception and design of the study. J.A and D.G to the acquisition of data, or analysis and interpretation of data. All authors contributed to drafting the article or revising it critically for important intellectual content. All authors approved the submission.

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