

1 **Non-operative treatment for partial ruptures of the fibular collateral**
2 **ligament occurring in combination with complete ruptures of the**
3 **anterolateral ligament: A common injury pattern in Brazilian Jiu-**
4 **Jitsu athletes presenting with acute knee injury**

5
6 Eduardo Frois Temponi, Adnan Saithna, Lúcio H Carvalho, Bruno Presses Teixeira,
7 and Bertrand Sonnery-Cottet

8
9 **Abstract**

10
11 **Background**

12 Combined partial lateral collateral and complete anterolateral ligament (PLCCALL) injuries
13 are a specific injury pattern seen in Brazilian Jiu-jitsu due to the knee varus/flexion
14 mechanism that frequently occurs during grappling.

15 **Purpose**

16 The aim of this article was to evaluate the incidence of this injury pattern in a series of
17 Brazilian Jiu-jitsu athletes with an acute knee injury, and also to evaluate clinical and
18 functional outcomes after non-operative management, at a minimum follow up of one year.

19 **Hypothesis**

20 Our hypotheses were that partial lateral collateral and complete anterolateral ligament
21 (PLCCALL) injuries are common in BJJ and that non-operative treatment is associated with
22 excellent clinical outcomes and return to the pre-injury level of sport

23 **Study Design**

24 Case series – cohort

25
26 **Methods**

27 All Brazilian Jiu-jitsu athletes presenting with an acute knee injury between July 2013 and
28 June 2017 who underwent MRI of the knee were included. A specific emphasis was placed
29 on identifying those whose imaging demonstrated PLCCALL injury. Clinical evaluation
30 included physical examination, Lysholm and International Knee Documentation Committee
31 (IKDC) score.

32 **Results**

33 Of the 27 patients analyzed, seven (25.9%) were identified to have MRI proven PLCCALL
34 injuries. The mean follow-up was 41.3 months. The mean IKDC/Lysholm score pre-injury
35 was 94.3/92, at initial assessment after injury was 26/35.6 and this improved to 82.8/78.2 at
36 12 months post-injury ($p < 0.00001$). All seven patients returned to the pre-injury level of
37 sports after one year of follow-up. The mean time between injury and return to competition
38 level was 4.7 months (range 4-6).

39 **Conclusion**

40 Combined partial LCL rupture and complete rupture of the ALL is a specific but infrequent
41 injury pattern in BJJ. The prognosis of this injury following non-operative treatment appears
42 to be excellent. Improved functional scores (IKDC and Lysholm) and MRI demonstrate that
43 the ALL has intrinsic healing potential because the images show complete healing of the
44 previously documented rupture of the anterolateral ligament from its proximal attachment.

45
46 **Clinical Relevance:** The present article primarily evaluates the incidence of a specific injury
47 pattern in a large series of Brazilian Jiu-Jitsu athletes with an acute knee injury, and also
48 evaluates clinical and functional outcomes of these patients. The second major finding of this
49 study is that these injuries can heal as proven by improved functional scores (IKDC e
50 Lysholm) and subsequent MRI, how has been debate in the recent literature.

51

52 **Keywords:** Anterolateral ligament, Fibular collateral ligament, Brazilian Jiu-Jitsu

53
54 **What is known about the subject:** Great discussion and numerous publications have been
55 made specifically on the anterolateral aspect of the knee. The majority of this has focused on
56 patients with ACL injuries but ALL in the absence of ACL rupture is not well reported. A
57 single previous case report has highlighted that partial LCL and complete ALL rupture is a
58 possibility in BJJ athletes however little further information is available to aid in diagnosis
59 and management

60
61 **What this study adds to existing knowledge:** To the knowledge of the authors this is the
62 first article that highlights this injury pattern as occurring frequently in BJJ patients with acute
63 knee injuries. This is an important finding because it will allow clinicians to hold an
64 appropriate index of suspicion for this injury. Furthermore, the article demonstrates that non
65 operative treatment of this injury pattern is associated with excellent clinical and functional
66 outcomes in these patients. Finally, a further important finding of this study is that these
67 specific injuries can heal with non operative treatment, as proven by improved functional
68 scores (IKDC e Lysholm) and subsequently on follow-up MRI as alluded to in other recent
69 publications

70 71 **Introduction**

72
73 In the last decade there has been a significant increase in the popularity of Brazilian Jiu-Jitsu
74 (BJJ).^{2, 23} In part, this is due to the success of BJJ techniques in the much larger sport of mixed
75 martial arts.^{14, 15, 19} Athletes start fighting from a standing position, but most of the combat
76 takes place in groundwork. The aim is to make the opponent submit by means of choke, joint
77 locks (wrist, elbow, knee and ankle locks) or pressure techniques.^{2, 17}

78
79 Despite the popularity of BJJ internationally, little is known about the incidence and spectrum
80 of injuries in this sport.^{17, 23} Scoggin et al. reported an injury rate of 9.2 per 1000 athlete-
81 exposures during BJJ competition, with the knee amongst the second most frequent area of
82 orthopedic injury (19.4% of all injuries).²³ Of particular note, 57% of knee injuries involved
83 the lateral collateral ligament, but detailed clinical and radiological evaluation was not
84 reported.²³

85
86 Claes et al. proposed the term lateral collateral ligament complex (LCLC) to encompass both
87 the lateral collateral ligament (LCL) and the anterolateral ligament (ALL).⁶ Since that time
88 there has been considerable discussion in the literature regarding the precise anatomy of the
89 anterolateral aspect of the knee and the term LCLC has been popularized. However,
90 numerous authors have reported that the proximal fibers of the LCL and ALL are often
91 integrated and so it would be logical to consider that combined injuries may occur.^{5, 11} Davis
92 et al reported a single case of combined partial rupture of the LCL and complete rupture of
93 the ALL in a BJJ athlete.⁷

94
95 The aim of this article was therefore to evaluate the incidence of this specific injury pattern
96 in a large series of BJJ athletes with an acute knee injury, and also to evaluate clinical and
97 functional outcomes, with a minimum follow up of one year.

98 99 **Materials and Methods**

100 Institutional Review Board approval was granted for this study. All BJJ athletes presenting
101 with an acute knee injury (within 2 weeks) between July 1, 2012 and June 30, 2017 at Hospital
102 Madre Teresa/Belo Horizonte-Brazil were invited to participate in the study. Informed
103 consent was obtained and patients were considered for study eligibility. Patients were only

104 excluded if they had a history of previous surgery, infection, arthritis, or injury to the
105 ipsilateral knee, or a concurrent ligament injury in addition to partial lateral collateral and
106 complete anterolateral ligament (PLCCALL) injury.

107
108 All patients underwent standard acute knee clinical examination and evaluation with plain
109 radiographs (non_weight bearing AP and lateral views, varus stress views (Figure 1) and
110 magnetic resonance imaging (MRI) within one week of the initial presentation, which varied
111 from one to three weeks of injury.¹⁵ The stress views were performed and interpreted by the
112 senior surgeon according to protocol described by LaPrade.²⁶ MRI was performed with a 1.5-
113 T magnet with a wide-bore configuration (MAGNETOM Avanto, Siemens, Munich,
114 Germany). In addition to standard MRI knee reporting practice, particular emphasis was
115 placed on identifying injury to the anterolateral knee structures (Figure 2).^{9, 25} In patients with
116 a combined partial rupture of the LCL and a complete rupture of the ALL a specific effort
117 was made to determine the precise mechanism of injury, including by video analysis of
118 trauma when available.

119 120 **MRI evaluation**

121 MRI scans were evaluated by a radiologist with more than 10 years of experience in
122 musculoskeletal radiology. Previously described radiological and anatomical descriptions
123 were used as a basis for interpretation.^{9, 25} The ALL was considered normal if continuous low
124 signal intensity fibers were seen traversing from the lateral femoral epicondylar region to the
125 anterolateral tibia. The ALL was considered to be abnormal, and was classified according to
126 Muramatsu et al.²⁰ if any of the following features were observed: complete disruption of
127 the ligament, abnormal contour or irregularity of ALL fibers and/or the presence of
128 ligamentous edema. Lateral collateral ligament injuries were graded (0–3) according to
129 equivalent Schweitzer et al for MCL.²² If the contour of the LCL was irregular or if
130 ligamentous edema existed then it was considered to be abnormal. All LCL injuries were
131 considered significant for the purpose of this study, according to Pacheco et al.²¹ For both the
132 LCL and ALL, if the contour of the structures analyzed was irregular or if ligamentous edema
133 existed, then the radiologists considered the structure to be abnormal. If only periligamentous
134 edema existed, with identifiable, continuous low-signal intensity fibers, the ligament was
135 considered intact.^{20, 21}

136 137 **Rehabilitation**

138 All patients with combined LCL and ALL injuries were treated non-operatively. This
139 consisted of immediate partial weight-bearing with a hinged knee brace (Ossur UK,
140 Stockport, England) locked with extension knee for 2 weeks. At this stage full weight-bearing
141 was allowed as was unrestricted motion within the brace for a further 4 weeks. All braces
142 were discarded at 6 weeks following the injury. Patient began physical therapy at 2 weeks.
143 Therapy included continuous passive motion (CPM) machine and application of a
144 cold/compression device (Cryocuff TM, DJ Orthopaedics, Vista, CA), already in this phase.
145 Once inflammation and swelling had settled and full symmetrical ROM was achieved,
146 strength and functional training were progressed gradually with a view to returning to sports
147 participation. Patients typically resume moderate activity (strengthening and aerobic training
148 in the gym avoiding pivot activities) 2 months after this injury and a full return to Jiu-Jitsu
149 competition at 3-6 months.

150 151 **Outpatient Follow-Up**

152 The senior surgeon reviewed all patients at 6 weeks, 3, 6, 12 months and beyond this time if
153 the patient returned for evaluation of another injury. Clinical outcome scores including the
154 International Knee Documentation Committee (IKDC)²⁴ and Lysholm score were recorded.⁴
155 ^{24.} All of the included patients were training under the supervision of jiu-jitsu centers and

156 based on previous physiotherapy records the pre-injury scores were obtained. Follow-up MRI
157 was not performed on all patients in order to evaluate healing, but only in two patients who
158 had repeat imaging to evaluate new injury. This additional imaging provided the opportunity
159 to evaluate the healing potential of the ALL.

160

161 **Data Analysis**

162 Descriptive data (mean, median, range, proportions) are reported for the entire patient cohort.
163 The SPSS, 20® (IBM Corp. 2011. IBM SPSS Statistics for Windows, 20.0 Armonk, NY: BM
164 Corp) software was used for all statistical analyses. Differences between means were tested
165 for normal distribution by 152 the D'Agostino-Pearson test and, the difference between the
166 averages were calculated by Student's T test. A *p* value ≤ 0.05 was considered statistically
167 significant.

168

169 **Results**

170 Of the 27 patients analyzed, seven (25.9%) were identified to have MRI proven partial injury
171 to the LCL and complete ALL rupture. All seven patients with PLCCALL injuries in this
172 series were male. Their mean age was 33 (± 10.5) years. The mean follow-up was 41.3 (range
173 22.1– 60.5) months. The mean IKDC score pre injury was 94.3, at initial assessment was 26
174 (± 3.1) and this improved to 82.8 (± 6.4) in postinjury at a follow up 12 months ($p < 0.00001$).
175 The mean Lysholm pre-injury was 92, at initial assessment was 35.6 (± 9.2) and 78.2 (± 10)
176 pre and postinjury ($p < 0.00001$). All seven patients returned to the pre-injury level of sport.
177 The mean time between injury and return to competition level was 4.7 months (range 4-6).

178

179 In all seven patients with a combined injury, MRI evaluation demonstrated a high grade
180 partial-thickness tear of the LCL (Schweitzer grade 2) at the femoral attachment and complete
181 rupture of the anterolateral ligament from its proximal attachment with the distal attachment
182 remaining intact. Varus stress physical examination findings and radiography demonstrated
183 that there was no increase in lateral compartment opening when compared to the uninjured
184 side in all patients ($p > 0.05$).

185

186 In the two patients who underwent repeat MRI (for a new knee injury) at approximately 12
187 months following the previous imaging, complete healing of the previously documented
188 partial ruptures of the lateral collateral ligament and anterolateral ligament was demonstrated
189 without any evidence of anatomical abnormalities (Figure 3).

190

191 **Discussion**

192 The most important finding of the present study was that partial rupture of the LCL and
193 complete rupture of the ALL occurred in the current series at a rate of approximately 25.9%
194 in BJJ athletes presenting with an acute knee injury. The rate of occurrence is sufficient to
195 highlight this specific pattern of injury to clinicians looking after athletes in this sport. This
196 should be particularly emphasized because, to the knowledge of the authors, it has previously
197 only been described in the sport of BJJ in a single case report.⁷

198

199 There is no doubt that the practice of BJJ has grown exponentially all over the world in the
200 last few decades.^{17, 23} As a consequence of this growth, researchers have strived to enhance
201 the quality of investigations into physical and physiological responses to training, combat
202 simulation and prevention of lesions in BJJ.^{1-3, 8, 14, 15} Little is known about injuries in this
203 sport and specific lesions around the knee have not been well described. There are many
204 dynamic positions that occur during BJJ competitions; one of these, the open guard has
205 evolved extensively in recent years. Multiple variations of this position and their associated
206 techniques include intricate entanglement of the limbs of both combatants, ultimately leading

207 to a significant increase in twisting and varus/valgus injuries of the lower extremities.^{1, 2, 7, 8,}
208 ^{14, 18} It is therefore very helpful to understand the specific mechanism involved when
209 evaluating an injured knee and video footage can be particularly useful. (Figure 4; Video 1).
210

211 Davis, et al. previously reported combined partial LCL and complete ALL rupture in a case
212 series of two patients.⁷ One of these was a BJJ athlete and the other was a rock climber.
213 Similar to the athletes in the current series the mechanism of injury in both cases reported by
214 Davis et al was also a varus force on a flexed knee, with varying degrees of external rotation.
215 This is important to highlight for two reasons. Firstly, this specific mechanism of injury
216 should raise the index of suspicion of this injury pattern when evaluating acutely injured
217 knees, particularly in those participating in BJJ. Secondly, it is should be recognize that ALL
218 ruptures more frequently occur with a typically valgus/internal rotation injury in the acutely
219 ACL injured knee (up to 90%).^{10, 12, 20} As a result, in the absence of ACL injury or the typical
220 mechanism leading to it, radiologists may not specifically assess the ALL, unless it is
221 highlighted when requesting the MRI, that injury to this structure should be considered with
222 the mechanism described above. Interestingly, all seven cases involved complete disruption
223 of the ALL and partial injury to the FCL from their proximal attachments. In the setting of
224 ACL injury, ALL ruptures are typically tibial sided and this difference is probably a reflection
225 of the different forces encountered at the time of injury.
226

227 Consistent with the experience reported with combined partial rupture of the LCL and
228 complete rupture of the ALL in the current study, Davis et al. also described full return to
229 sport after non-operative treatment using a similar rehabilitation protocol.⁷ This suggests that
230 there is a high likelihood of return to competition with non operative treatment. The mean
231 duration of time between injury and return to sport was 4.7 months (range 4-6 months) and
232 this is useful information for athletes and those looking after them. It should be noted that
233 this is also broadly consistent with the cases reported by Davis et al who described return to
234 competition in a BJJ athlete at 7 months, and return to full function in a rock climber at 6
235 months.
236

237 A further important finding of the current study was that partial LCL and complete ALL
238 injuries have the potential to heal with non-operative management, as proven by MRI
239 evaluation in two patients. There has been debate in the literature as to whether ALL injuries
240 can actually heal with non-surgical treatment. Muramatsu et al, reported a significantly lower
241 rate of ALL injuries in chronic ACL injured knees when compared to acutely ACL-injured
242 knees, and postulated that this may be due to an intrinsic healing potential.²⁰ The authors
243 recommended longitudinal study to evaluate this concept further. To our knowledge the
244 current study is the first to evaluate and confirm the intrinsic healing potential of complete
245 ALL ruptures using MRI evaluation.
246

247 **Limitations**

249 The main limitation of this study is the fact that the series comprised only 7 cases and there
250 was follow-up imaging available on only 2 of 7 patients. Clearly, larger series are required to
251 understand more precisely the spectrum of recovery following this injury and gain a more
252 accurate impression of its incidence. However, the overall cohort of 27 acutely injured knees
253 in BJJ athletes was considered to represent a significant clinical experience and considerably
254 larger volume of cases when compared to previously published literature evaluating knee
255 injuries in this sport.
256

257 **Conclusion**

258 Clinicians treating BJJ athletes with acute knee injuries should hold an appropriate index of
259 suspicion for partial LCL rupture and complete rupture of the ALL based on the high
260 frequency with which it was observed in this study. MRI evaluation in a limited number of
261 patients demonstrates that the ALL has intrinsic healing potential and non-operative treatment
262 appears to be associated with excellent outcomes based on return to the pre-injury level of
263 sport in all athletes in this series.

264

265 **References**

266

- 267 1. Andreato LV, Julio UF, Goncalves Panissa VL, et al. Brazilian Jiu-Jitsu Simulated
268 Competition Part II: Physica Performance, Time-Motion, Technical-Tactical Analyses, and
269 Perceptual Responses. *J Strength Cond Res.* 2015;29(7):2015-2025.
- 270 2. Andreato LV, Lara FJD, Andrade A, Branco BHM. Physical and Physiological Profiles of
271 Brazilian Jiu-Jitsu Athletes: a Systematic Review. *Sports Med Open.* 2017;3(1):9.
- 272 3. Andreato LV, Santos JF, Esteves JV, Panissa VL, Julio UF, Franchini E. Physiological,
273 Nutritional and Performance Profiles of Brazilian Jiu-Jitsu Athletes. *J Hum Kinet.*
274 2016;53:261-271.
- 275 4. Bollen S, Seedhom BB. A comparison of the 276 Lysholm and Cincinnati knee scoring
276 questionnaires. *Am J Sports Med.* 1991;19(2):189-190.
- 277 5. Caterine S, Litchfield R, Johnson M, Chronik B, Getgood A. A cadaveric study of the
278 anterolateral ligament: re-introducing the lateral capsular ligament. *Knee Surg Sports*
279 *Traumatol Arthrosc.* 2015;23(11):3186-3195.
- 280 6. Claes S, Vereecke E, Maes M, Victor J, Verdonk P, Bellemans J. Anatomy of the
281 anterolateral ligament of the knee. *J Anat.* 2013;223(4):321-328.
- 282 7. Davis BA, Hiller LP, Imbesi SG, Chang EY. Isolated lateral collateral ligament complex
283 injury in rock climbing and Brazilian Jiu-jitsu. *Skeletal Radiol.* 2015;44(8):1175-1179.
- 284 8. Detanico D, Dellagrana RA, Athayde MS, Kons RL, Goes A. Effect of a Brazilian Jiu-
285 jitsu-simulated tournament on strength parameters and perceptual responses. *Sports Biomech.*
286 2017;16(1):115-126.
- 287 9. Devitt BM, Whelan DB. Physical examination and imaging of the lateral collateral
288 ligament and posterolateral corner of the knee. *Sports Med Arthrosc.* 2015;23(1):10-16.
- 289 10. Ferretti A, Monaco E, Fabbri M, Maestri B, De Carli A. Prevalence and Classification of
290 Injuries of Anterolateral Complex in Acute Anterior Cruciate Ligament Tears. *Arthroscopy.*
291 2017;33(1):147-154.
- 292 11. Helito CP, Demange MK, Bonadio MB, et al. Anatomy and Histology of the Knee
293 Anterolateral Ligament. *Orthop J Sports Med.* 2013;1(7):2325967113513546.
- 294 12. Helito CP, Helito PV, Costa HP, et al. MRI evaluation of the anterolateral ligament of the
295 knee: assessment in routine 1.5-T scans. *Skeletal Radiol.* 2014;43(10):1421-1427.
- 296 13. Herbst E, Albers M, Burnham JM, Fu FH, Musahl V. The Anterolateral Complex of the
297 Knee. *Orthop J Sports Med.* 2017;5(10):2325967117730805.
- 298 14. Jensen AR, Maciel RC, Petrigliano FA, Rodriguez JP, Brooks AG. Injuries Sustained by
299 the Mixed Martial Arts Athlete. *Sports Health.* 2016.
- 300 15. Ji M. Analysis of injury types for mixed martial arts athletes. *J Phys Ther Sci.*
301 2016;28(5):1544-1546.
- 302 16. Kraeutler MJ, Welton KL, Chahla J, LaPrade RF, McCarty EC. Current Concepts of the
303 Anterolateral Ligament of the Knee: Anatomy, Biomechanics, and Reconstruction. *Am J*
304 *Sports Med.* 2017;363546517701920.
- 305 17. Kreiswirth EM, Myer GD, Rauh MJ. Incidence of injury among male Brazilian jiu-jitsu
306 fighters at the World Jiu-Jitsu No-Gi Championship 2009. *J Athl Train.* 2014;49(1):89-94.
- 307 18. Lima PO, Lima AA, Coelho AC, et al. Biomechanical Differences in Brazilian Jiu-Jitsu
308 Athletes: The Role of Combat Style. *Int J Sports Phys Ther.* 2017;12(1):67-74.

- 309 **19.** McClain R, Wassermen J, Mayfield C, Berry AC, Grenier G, Suminski RR. Injury profile
310 of mixed martial arts competitors. *Clin J Sport Med.* 2014;24(6):497-501.
- 311 **20.** Muramatsu K, Saithna A, Watanabe H, Sasaki K, Yokosawa K, Hachiya Y, Banno
312 T, Helito CP, Sonnery-Cottet B.. Three-dimensional Magnetic Resonance Imaging of
313 the Anterolateral Ligament of the Knee: An Evaluation of Intact and Anterior
314 Cruciate Ligament-Deficient Knees From the Scientific Anterior Cruciate Ligament Network
315 International (SANTI) Study Group. *Arthroscopy.* 2018 Jul;34(7):2207-2217.
- 316 **21.** Pacheco RJ, Ayre CA, Bollen SR. Posterolateral corner injuries of the knee: a serious
317 injury commonly missed. *J Bone Joint Surg Br.* 2011;93(2):194-197.
- 318 **22.** Schweitzer ME, Tran D, Deely DM, Hume EL. Medial collateral ligament injuries:
319 evaluation of multiple signs, prevalence and location of associated bone bruises, and
320 assessment with MR imaging. *Radiology.* 1995;194(3):825-829.
- 321 **23.** Scoggin JF, 3rd, Brusovanik G, Izuka BH, Zandee van Rilland E, Geling O, Tokumura
322 S. Assessment of Injuries During Brazilian Jiu-Jitsu Competition. *Orthop J Sports Med.*
323 2014;2(2):2325967114522184.
- 324 **24.** Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. *Clin*
325 *Orthop Relat Res.* 1985(198):43-49.
- 326 **25.** Temponi EF, de Carvalho Junior LH, Saithna A, Thaunat M, Sonnery-Cottet B. Incidence
327 and MRI characterization of the spectrum of posterolateral corner injuries occurring in
328 association with ACL rupture. *Skeletal Radiol.* 2017;46(8):1063-1070.
- 329 **26.** LaPrade RF, Heikes C, Bakker AJ, Jakobsen RB. The reproducibility and repeatability of
330 varus stress radiographs in the assessment of isolated fibular collateral ligament and grade-III
331 posterolateral knee injuries. An in vitro biomechanical study. *J Bone Joint Surg Am.* 2008
332 Oct;90(10):2069-76.

333

334

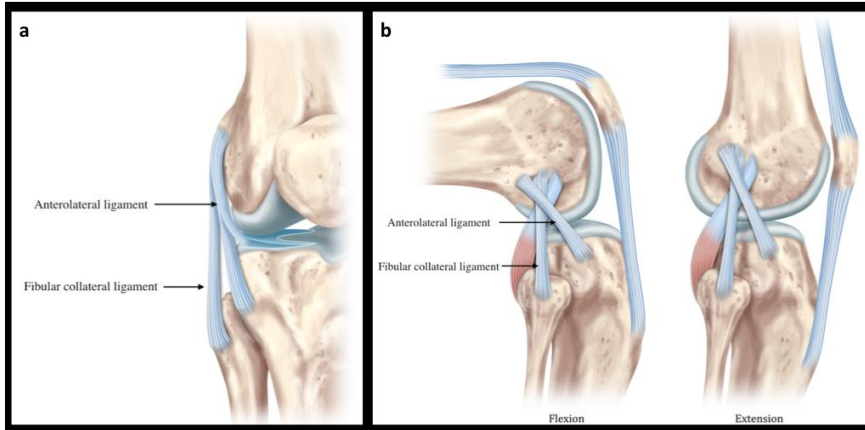
335 **Figures and Video**

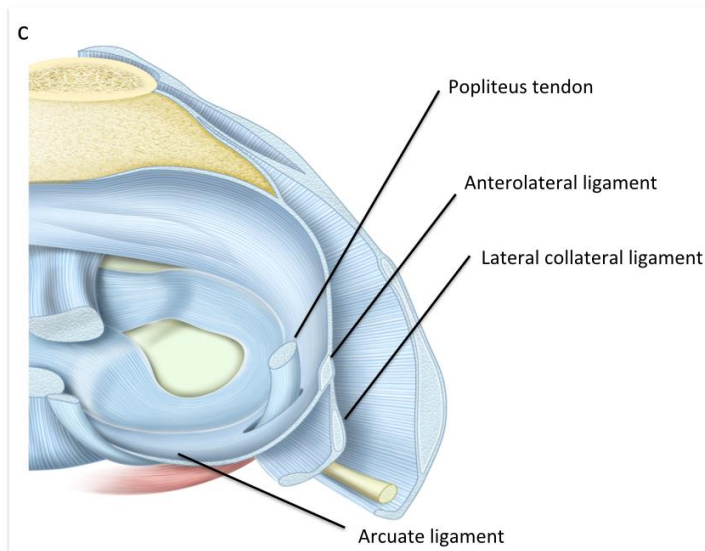
336

337 **Figure 1)** Radiographic images comparing the normal (right) and injured (left) sides a) AP
338 view, b) AP stress 0° flexion view, AP stress 30° flexion view.



339
 340 **Figure 2)** Illustration demonstrating the normal anatomy of the lateral corner of a right knee
 341 a) coronal view b) sagittal views in flexion and extension c) axial view
 342





344
 345 **Figure 3)** MRI images of the partial lateral collateral ligament and complete anterolateral
 346 ligament immediately post-injury and at one year of follow-up a) coronal T2 image
 347 demonstrating LCL, b) coronal T2 image demonstrating ALL, c) axial T2 image
 348 demonstrating lateral collateral ligament complex

349
 350 **Figure 4)** Photograph of the major positions that occur during BJJ related with this injury
 351 pattern a) Gogoplata, b) De la Riva guard, c) Bottleneck, d) 50/50 guard

352
 353 **Video 1)** Video demonstrating the normal anatomy of the lateral corner of knee and the major
 354 positions related with this injury pattern that occur during BJJ

355
 356