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# Medial collateral ligament lengthening by standardized pie-crusting technique: A cadaver study

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ABSTRACT

*Introduction:* Pie-crusting (PC) is a tissue expansion technique using multiple perforation to lengthen the medial collateral ligament (MCL), but has still to be codified.
*Hypothesis:* Standardized MCL PC allows measured opening of the medial femorotibial (MFT) joint line, without risk of MCL tear.
*Material and method:* Thirty-one knees were dissected, with medial parapatellar arthrotomy and resection of the cruciate ligaments and menisci. The deep MCL bundle was sectioned, and the thick anterior bundle (AB) of the MCL was observed in each knee. Knees were randomly allocated between AB sparing (AB+; $n = 15$) or sectioning (AB−; $n = 16$). A graduated dynometric tensor applied constant 80 N distraction on the MFT joint line. MCL PC used a 19-G needle at the joint line, with a horizontal series of perforations every 2 mm over the width of the MCL. MFT compartment opening was measured after each PC series.
*Results:* Mean MFT space after sectioning the cruciate ligaments was 5.52 ± 0.37 mm, increasing by 1.64 ± 1.28 mm with AB sectioning. Twenty-five perforations were made in the AB+ and 16 in the AB− group. Final mean joint-line increase was 0.18 ± 0.18 mm in AB+ and 3.16 ± 2.70 mm in AB−. There were no MCL tears.
*Discussion:* MCL pie-crusting was reliable and reproducible, achieving progressive MFT joint-line lengthening to a mean 8.71 ± 2.62 mm when associated to sectioning of the cruciate ligaments and MCL AB.
*Type of study:* Cadaver.
*Level of evidence:* IV.



## 1. Introduction

Varus knee is the most frequent deformity encountered during total knee arthroplasty [1–3]. Although controversial as main factor of implant survival, femorotibial alignment remains a major objective in total knee replacement [4–6]. Bone deformity is addressed by bone cuts perpendicular to the mechanical axis, inducingh a trapezoid-shaped articular extension gap with a short medial side. Gap balancing usually involves medial collateral ligament (MCL) lengthening [1,3,7–9] to widen the medial femorotibial (MFT) compartment. The conventional technique consists in subperiosteal release at the MCL foot, with risk of "all or nothing" lengthening, inducing real medial laxity once the whole MCL has been detached from the tibia, even with differentiation between posterior and anterior MCL bundle detachment as proposed by L.A. Whiteside [10,11]. The superficial MCL bundle plays a key role in medial stability, especially if the cruciate ligaments have been sectioned [2,7,12–15], and it is therefore mandatory to use a surgical technique allowing progressive MCL lengthening. The pie-crusting (PC) technique serves this purpose.

PC was recommended by several authors to lengthen the MCL [1,9,16,17]. It consists in performing series of multiple horizontal incisions in the mid-part of the MCL, allowing progressive adjustment of lengthening and avoiding complete detachment of the ligament [17]. It has long been described for lengthening the iliotibial band and correcting genu valgum [18–21]. Although increasingly widely used, the technique and its limitations remain to be fully codified. Bellemans et al. published a precise description, and suggested multiple needle puncturing [16]. Verdonk et al. [2] recommended PC in severe varus deformity requiring more than 6–8 mm correction, and reported reproducible and

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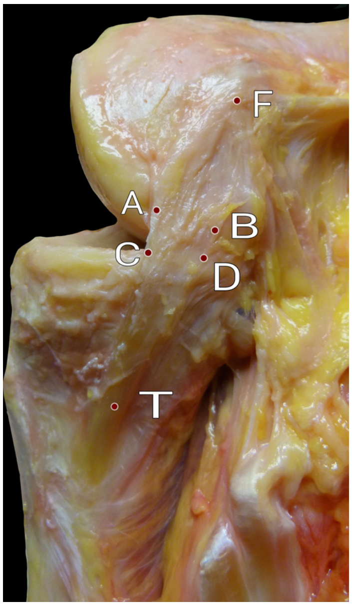


**Fig. 1.** Medial collateral ligament dimensions. F: femoral epicondyle summit; T: tibial enthesis insertion center; A–D: respectively, anterior femoral, posterior femoral, anterior tibial and posterior tibial bone/cartilage junctions. The distances observed were F-T, A-C and B-D.


**Fig. 2.** Anterior bundle of the medial collateral ligament.

satisfactory results. Other authors, however, were not always able to reproduce these results, and suggested that PC may not be indicated for the MCL, inducing a fairly substantial risk of iatrogenic tear [17].

Considering these contradictory reports, we analyzed MCL lengthening during PC performed following the original protocol [16]. The objective of the present cadaver study was to describe progressive MCL lengthening, so as to quantify MFT compartment opening and standardize the technique. The study hypotheses were: that there is a region of maximal resistance in the anterior part of the MCL; that needle PC according to Bellemans et al. [16] can be performed reproducibly, without risk of ligament tear; and that the MFT compartment opening achieved by a predefined perforation pattern can be quantified.

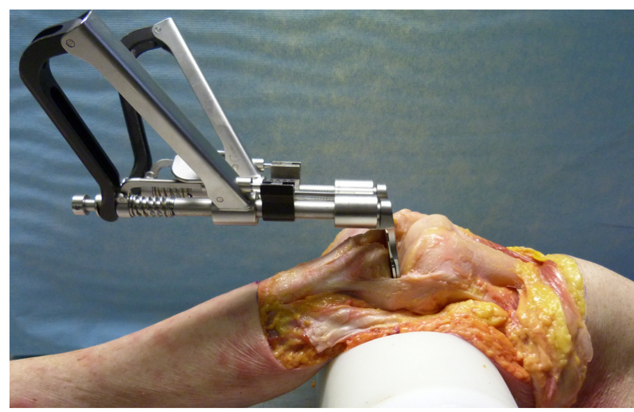

**Fig. 3.** Knee prepared for pie-crusting: slight flexion and dynamometric tensor in position.

## 2. Material and method

Lower limbs were obtained from fresh caucasian cadavers (Pr. S. Velut's anatomy laboratory, Tours Medical School, Center-West Body Donation Association). Limbs showing history of knee surgery or clinical deformity were excluded.

Dissection began with a laterally hinged cutaneous incision of the inferior third of the thigh down to 4 finger-widths from the tibial tuberosity. Medial parapatellar arthrotomy was performed, followed by resection of the infrapatellar fat pad, cruciate ligaments and menisci. The hamstring tendons were released. The medial joint capsule was resected up to the anterior edge of the MCL. The deep MCL bundle was systematically released and osteophytes were resected. A support held the knee in 20° flexion to relax the posterior capsules and ensure tensioning of the sole MCL [12].

MCL landmarking used subcutaneous needles (Fig. 1): F (femoral epicondyle summit), T (tibial enthesis insertion center), A, B, C and D (respectively, anterior femoral, posterior femoral, anterior tibial and posterior tibial bone/cartilage junctions). The thick anterior MCL segment was referred to as the "anterior bundle" (AB) (Fig. 2). Knees were randomly allocated to one of two groups, conserving or sectioning AB (AB+ and AB−, respectively) after baseline reference measurements had been taken.

A ligament-tensioning device (SYS 251199-B7, Smith & Nephew Inc., Memphis, TN, USA) was introduced into the femorotibial space to apply a force of 80 Newtons (Fig. 3). This force of 80 newtons was selected to avoid plastic deformation of the collateral ligaments, following the manufacturer's recommendations and the literature data [12,22].

Reference measurements of the F-T, A-C, B-D and F-A distances and MFT space were made with the tensioning device in position. In the AB- group, AB sectioning was then performed.

PC was performed with a 19-gauge lumbar puncture needle. In-out perforations were made perpendicular to the MCL fibers, adjacent to the MFT joint line, every 2 mm over the whole width of the MCL, the number being limited by the available MCL area. Three PC series were performed, at 2-mm intervals; F-T, A-C, B-D, and F-A distances and MFT space were measured after each series. Then two final series were performed, with perforations in-between those of the first three, and final measurements were taken (Fig. 4).

Specimens served as their own controls. Bilateral specimens were treated as independent. Statistical analysis used non-parametric Mann-Whitney and Wilcoxon tests, due to small sample size, on StatView software, v 5.0 (Abacus Concepts, Inc. Piscataway, NJ, USA). The significance threshold was set at 5% ($P \leq 0.05$).