

Pie-Crusting Technique of Medial Collateral Ligament for Total Knee Arthroplasty in Varus Deformity: A Systematic Review

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Abstract

Background: We aimed to better understand the outcomes/complications of pie-crusting technique using blade knife during total knee arthroplasty (TKA) in patients with knee genu varum deformity.

Materials and Methods: A systematic search was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines. English and Persian language articles were considered on the use of pie-crusting technique during TKA in patients with knee genu varum/varus deformity using related keywords and Medical Subject Headings terms with reported postoperative complications and outcomes.

Results: Primary search resulted in 81 studies of them 9 included in our study (ages ranged: 19 years to 62 years). No perioperative complications and/or any significant differences between pie-crusting and control group were observed. Except for two studies that found no significant positive effect for the use of pie-crusting, other studies found pie-crusting a useful and promising technique. Four studies found significant improvement in pie-crusting group compared to control in terms of functional Knee Society Score (KSS), range of motion (ROM), medial gap, and the knee-specific KKS. Three records found no significant differences in terms of functional KSS, ROM; however, they reported fewer use of constrained inserts or a reasonable correction of femoral tibial angle. No serious complications were reported.

Conclusions: Due to the inconsistency of the results on the efficiency and outcomes of pie-crusting, we cannot make a firm conclusion and more high-quality studies are needed in this regard. However, this method can be considered as a safe method which depends on the skill of surgeon.

Keywords: Arthroplasty, instability, medial collateral ligament, pie-crusting, systematic review, total knee replacement

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INTRODUCTION

Genu varum weakens the lateral structure and consequently makes it difficult to improve the stability of patients' knee joint using conventional correction methods.^[1,2] Genu varum or varus has a great negative impact on the quality of life of the patient's due to impairment of their ability to live independently. Total knee arthroplasty (TKA) is a promising and relatively new treatment approach which can improve the quality of life of these patients effectively.^[3] Preparation of medial structures of the knee for varus

deformity correction is one of the most important factors during TKA.^[4,5]

Various soft tissue release techniques were developed to correct an unbalanced joint. Among these techniques, the traditional release method, also known as the insall release method, has become a popular method for releasing contractile soft tissue with clinically verifiable results reported by several studies.^[6-10] However, some studies have found the complications of this procedure to be worrisome including unstable knees due to

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excessive release or increased joint line ultimately might lead to patellar and osteoarthritis due to arterial damage around the joint.^[11-13]

The needle multiple puncture technique for medial collateral ligament (MCL) release is widely used in varus deformity in total arthroplasty surgery, and the pie-crusting technique using blade knife in recent years has been considered as a damage-control method to release soft tissue of lateral structures in total valgus deformity arthroplasty.^[14-18] Some studies have reported this method is effective and uncomplicated in releasing the medial tissues of the knee with a blade knife.^[16,19,20] However, many surgeons still oppose the use of this technique due to iatrogenic damage to the superficial part of the MCL and possible instability of the knee joint.^[14,21-23] In a study on cadaveric knees, the safety of this technique on MCL showed that surgeons should be careful in using this technique because the failure mechanisms of this technique are different from those commonly used.^[23]

To best of our knowledge, no systematic review has been conducted to investigate the effects and safety of pie-crusting technique on the different parameters of the knee for varus deformity. The aim of this study was to systematically evaluate and summarize the clinical outcome and complications of pie-crusting of the medial side of the knee during TKA in patients with knee genu varum deformity.

MATERIALS AND METHODS

A systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines using a PRISMA checklist. Databases of Google Scholar, PubMed, Web of Science, Scopus, and scientific information database were searched systematically from 1990 to 2021. Inclusion criteria were studies in Persian or English, evaluating the clinical outcome of pie-crusting of the medial side of the knee during TKA in patients with knee in genu varum/varus deformity. The utilized keywords were the followings: “total knee arthroplasty,” “pie-crusting,” “genu varum” “genu varus,” “varus,” and “medial collateral ligament.” The following data were extracted from enrolled articles: first author’s name, publication year, country, study design, number of patients in pie-crusting group, knee brace usage, knee instability, outcomes, and complications. All the studies were entered in reference management EndNote software, and then, duplicates were removed followed by excluding the articles with undesired title and/or abstracts, conferences and abstracts, non-English and non-Persian articles, and studies published before 1990.

RESULTS

The process of study selection has shown in Figure 1. After removing duplications and unrelated articles, 13 studies were remained and one record was excluded because it was about

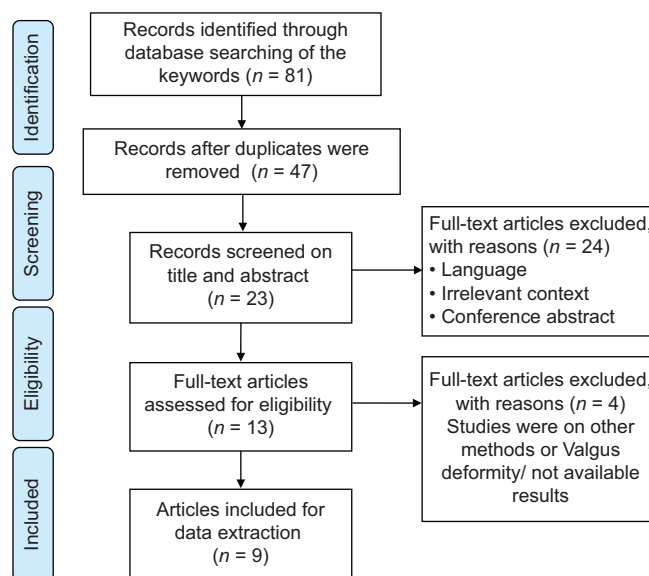


Figure 1: Flowchart of study selection procedure in this systematic review

valgus deformity.^[16] Another study was also removed because it introduced and used a new method called femoral origin release of the medial collateral ligament.^[24] One study was discarded because it did not provide any specific and separate data on patients in varus deformity.^[25] At last, we excluded one record since it was about medial epicondylar osteotomy method.^[26] Finally, 9 studies were selected.^[21,23,27-33] The summary of the outcomes of pie-crusting technique and patient follow-up for varus deformity during TKA has been listed in Table 1.

DISCUSSION

We performed this systematic literature review to evaluate clinical outcomes on different parameters after using pie-crusting technique during TKA in patients with varus deformity. In these recruited studies, men were treated more often than women, patients’ ages ranged from 19 to 62 years. Except for two studies that opposed the efficiency and safety of pie-crusting technique,^[23,34] other studies found pie-crusting a useful and promising technique.^[27-31,33] Among the studies evaluated this usefulness of this technique, one record reported some cases with knee instability followed by using pie-crusting technique during TKA,^[29] however, others reported no case of knee instability. Bracing was used for a mean of 4 weeks after percutaneous lengthening in two studies.^[29,30] At the final follow-up, no reports of any postoperative complications were found. Five studies reported improvement in KSS and range of motion (ROM) score and improving medial gap^[29-33] and two records found no significant improvement in terms of KSS and ROM.^[27-28]

The knee joint plays a very important role in supporting the body and transferring its weight during static and dynamic activities.^[35-37] Knee deformities cause premature osteoarthritis changes by unequal application of force to the internal and external structures of the knee.^[38] In general, the most

Table 1: The summary of the outcomes of pie-crusting technique for varus deformity during total knee arthroplasty

Author, year	Country	Study design	Number in pie-crusting group (knees)	Outcomes	Knee brace usage	Knee instability	Complications/others
He <i>et al.</i> , 2018 ^[90]	China	Retrospective study	26	Pie-crusting can achieve a comparable or even better effect of alignment correction. Postoperation FTA was improved with a statistical difference ($P=0.045$) The mean postoperative flexion contracture was 1.2 ± 3.6 The mean postoperative ROM was 104.0 ± 14.4 The mean postoperative hospital for special surgery knee score point was 82.0 ± 7.4 points The level of joint line elevates around 2.1 ± 1.9 mm	4/26	0/26	No patients reported medical complications Four patients had problem with climbing the stairs and 1 had difficulty in walking. 1 reported pain affected daily activity. No one reported pain in the release section. 5 reported moderate pain
Motifard <i>et al.</i> , 2021 ^[29]	Iran	Retrospective study	653	Pie-crusting were done in all 653 knees and the data compared between two groups: 35 repaired MCL after tearing during surgery and control group (618) The mean KSS was 88 ± 3 The mean ROM was $103\pm 11^\circ$ There were no differences between KSS scores and ROM degrees in repaired and nonrepaired group	2/35 (among repaired group)	12/653	35 knees (5%) experienced excessive medial opening (>4 mm) intraoperatively due to the midsubstance MCL tear; hence, they were repaired by suture Revision surgery to the CCKP was performed for three patients in nonrepaired group 16 knees in the noncomplicated group (2.5%) were revised due to instability and infection in 7 knees (1.1%) and 9 knees (1.4%), respectively No revisions were required for instability, and no constrained condylar inserts were used Four patients developed arthrofibrosis and were treated with manipulation under anesthesia
Crockarell 2015 ^[92]	USA	Retrospective study	246	Pie-crusting of the medial side of the varus knee is a predictable, reliable technique resulting in a well-aligned, well-balanced total knee arthroplasty Anatomic alignment improved from 5.9° varus (range $1-20^\circ$ varus) -4.7° valgus (range 2° varus -11° valgus). KSS averaged 76 points (range: 29-90)	NA	0/246	In the pie-crust group, all of the failures (17 failure cases) had extension gap imbalance. For all failure cases, additional pie-crust technique was applied, and the MCL balance with 2 mm was finally achieved in all cases
Ahn <i>et al.</i> , 2016 ^[93]	Korea	Prospective randomized controlled trial	106	The success rate was 67.9% in the pie-crust groups For the change in medial gap in knee flexion, a significant change was found in the pie-crust group ($P<0.001$) Mean medial gap changes in knee flexion were 1.1 ± 0.5 and 2.3 ± 1.2 mm in the reduction osteotomy and piecrust groups, respectively Pie-crust technique was more effective in flexion gap balancing	NA	0/53	At 6 weeks, 4 months, and 1-year postoperatively, there was no new-onset valgus instability indicating postoperative MCL rupture. No patients underwent manipulation under anesthesia in the study group, whereas 3.5% (eight patients) in the control group were manipulated ($P=0.21$)
Amundsen <i>et al.</i> , 2017 ^[28]	USA	Retrospective study	72	The use of constrained inserts was significantly lower in the pie-crust group than in the control group (5.3 vs. 13.8%, respectively) ($P=0.049$) The changes in the functional KSS and knee-specific KSS were similar in pie-crust and control patients ($P=0.48$ and $P=0.35$ for functional KSS and knee-specific KSS, respectively)	NA	0/72	No specific complications related to our technique were identified
Ha <i>et al.</i> , 2016 ^[91]	China	Retrospective study	729	The KSS knee score was improved from 52.5 to 83.4, KS function score from 58.2 to 91.9 ($P<0.001$)	NA	0/729	No specific complications related to our technique were identified

Contd...

Table 1: Contd...

Author, year	Country	Study design	Number in pie-crusting group (knees)	Outcomes	Knee brace usage	Knee instability	Complications/others
Kwak <i>et al.</i> , 2016 ^[21]	Korea	NA	10	The width of medial joint gap increment after each blade puncture and the number of punctures required for a specific size of medial gap increase were unpredictable. In addition, unexpected early over-release occurred with the pie-crusting technique.	NA	7/10	Overall, 70% of over-release occurred earlier than the average number of punctures leading to over-release.
Goudarz Mehdikhani <i>et al.</i> , 2016 ^[21]	USA	Retrospective study	188	The use of constrained inserts was significantly lower in study than in control patients (8% vs. 18%; <i>P</i> < 0.002). There was no difference in the KSS and range of motion between the groups at last follow-up.	0/188	0/188	No patient developed postoperative medial instability. No patients reported medical complications.
Meneghini <i>et al.</i> , 2013 ^[23]	USA	NA	28	The stiffness, force, and stress required to cause ligament elongation were less in the pie-crusting group (<i>P</i> = 0.05) compared to the control group but were not statistically different than the traditional group. The pie-crusting group demonstrated a characteristic "stair-step" failure mode at the joint line. MCL pie-crusting is likely technique dependent since failure occurs within the ligament itself.	NA	14/14	The pie-crusted ligaments showed multiply stair step like break points before reaching ultimate failure. Each small step had a partial failure at a hole within the ligament due to the technique and would show a short drop in the force that was being applied before it started to climb again to even greater force. All the pie-crusted ligaments showed multiply points of failure all at the joint line, where the traditional and control group showed tearing down only at the tibial attachment.

ROM: Range of motion, KSS: Knee society score, FTA: Femoral tibial angle, NA: Not available, MCL: Medial collateral ligament, CCKP: Constrained Condylar Knee Prosthesis

common cause of varus deformity is osteoarthritis, followed by rheumatoid arthritis and traumatic arthritis.^[39] Recommended treatments for this deformity include supportive measures, tibial osteotomy, and, finally, knee arthroplasty. There are many concerns about the techniques required for total arthroplasty in these patients.

Preparation of medial structures of the knee is one of the most important factors involved in TKA in patients with genu varum. Improper balance of medial knee structures causes premature failure after surgery.^[40-43] Several techniques have been proposed to create this balance.^[14,19,41,44] So far, no definitive standard for the technique of releasing the medial structures of the knee has been presented. Normally, the superficial part of the MCL is released subperiosteally to balance the medial structures in the varus knees.^[41,45,46] In one study, it was shown that by releasing surface MCL subperiosteally from the tibial insertion site by nearly 20 mm, the medial gap will be increased.^[47] Although in moderate deformity of the knee, less than a 10 mm increase in medial gap is required, the use of this common technique results in the loss of sufficient MCL tension and instability in the knee. Therefore, the use of this technique to increase the medial gap is discussed, while it depends on the skill of the surgeon. Aglietti *et al.* mentioned that pie-crusting is a reliable technique for correcting moderate-to-severe fixed valgus deformities and the rate of complication is very low while the mid-term outcomes are reasonable.^[16] Pie-crusting first introduced by Agneskirchner for soft-tissue balancing during TKA.^[17,18,35] The advantages of percutaneous release method are the release without compromising the synovial membrane, reducing the risk of intra-articular septic complications, while avoiding intra-articular structures that may prevent the tools needed in the intra-external method from being placed to use deep MCL.

Goudarz Mehdikhani *et al.* used an algorithmic method of pie-crusting recommended previously by Bellemans *et al.*^[14] which included the resection of the posterior osteophytes as the initial balancing gesture.^[27] They found that the use of constrained inserts was significantly lower in the pie-crusting group than the control group, and the difference in the constrained inserts applying was not significant in patients with mild and moderate deformity but it was only significant in those with severe deformity. They found no significant differences between pie-crusting and control groups in terms of functional KSS, ROM, and the knee-specific KKS. However, He *et al.* during their study on pie-crusting group including 36 patients (26 females and 10 males) with 39 knees concluded that pie-crusting method is effective, reliable, and safe to release superficial MCL (sMCL) for TKA.^[30] To perform pie-crusting, they made three to five small incisions in the middle of the ligament material with a scalpel or a scraping needle, and the contraction gap was gradually released with the diffuser simultaneously. The release range was controlled in range of 2–5 mm. Comparing the radiographic result of traditional release group with

pie-crusting group showed a reasonable correction of femoral tibial angle ($P = 0.045$) in the latter group indicated a higher valgus degree. Tibia osteotomy volume and plate thickness found to be greater in pie-crusting. Knee functional parameters improved significantly in terms of flexion contraction, ROM, and KSS points in the follow-up cases compared to their status before the operation. In their study, four out of 26 patients used braces to prevent knee instability, and all four removed the braces after some time without signs or symptoms of unstable knees. There was only one case with severe pain around patella restricted daily activities such as climbing stairs and walking; however, no hemarthrosis cases were reported in their study during follow-up period. The joint line levels were elevated approximately 2 mm using pie-crusting after surgery.^[30]

In study by Ha *et al.*, selective medial release method was performed for medial tightness applying pie-crusting. They found that out of 729 knees, 328 needed pMCL/PMCS scaling to release internal contractions. The ROM was improved from 127.4 to 140.8 and the KSS score from 52 to 83.4. The KSS function scores improved from 58.2 to 91.9 points. No patient disclosed signs of knee instability at the latest follow-up visit. No other specific medical complications related to this technique (bleeding, hematoma formation, constrained prosthesis, nerve injury) were reported.^[31] Controlled enhancement of sMCL allows for improved visualization and access to tools with the usage of percutaneous pie-crusting method.^[35]

However, studies on medial pie-crusting are not enough but it seems useful method for increasing medial gap especially in flexion. This theory has not been confirmed in Cadaveric studies. Several studies reported improvement in post-operative KSS and Functional KS after pie-crusting compared with pre-operative scores but in studies the control group was not considered for comparison. Therefore it is not possible to comment on the preference of this method over the traditional method. Some studies reported instability and CCK surgery has been less than the traditional method. Due to the inconsistency of the results on the efficiency and outcomes of pie-crusting we cannot make a firm conclusion and more high-quality studies are needed in this regard. However, this method can be considered as a safe method which depends on the skill of surgeon.

One of the main limitations of this study was that all the included studies were observational and they will have all the limitations of this category of studies.

CONCLUSIONS

It can be concluded that pie-crusting is a reliable method for correcting varus deformity (genu varum) and this technique is associated with low risk of instability, however in terms of knee society score (KSS) and range of motion (ROM) results of different articles are inconsistent and more studies are needed to confirm the conclusion.

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Conflicts of interest

There are no conflicts of interest.

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