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Anterior cruciate ligament reconstruction combined to partial knee replacement in active patients with ACL deficiency and knee osteoarthritis

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TITLE PAGE

Title: Anterior cruciate ligament reconstruction combined to partial knee replacement in active patients with ACL deficiency and knee osteoarthritis

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ABSTRACT

Objectives: To report, through a systematic review of the literature, the **clinical and radiographic outcomes** of unicompartmental knee replacement (UKR) combined to anterior cruciate ligament (ACL) reconstruction. It was hypothesized that this combined technique is a safe and effective procedure providing satisfactory post-operative functional outcomes.

Methods: A systematic review was performed by searching Pubmed/MEDLINE, CINAHL, SCOPUS, Embase and Ovid. Only studies in English pertaining all levels of evidence reporting on subjects with medial osteoarthritis and ACL deficiency undergoing UKR combined to ACL reconstruction were considered. Review articles and expert opinion or editorial pieces were excluded. Outcomes of interest included indications, clinical assessment including activity level, associated procedures, rate of complications such as revision surgery

Results: Overall, **9** studies met all the inclusion criteria for this review. All were published between 2006 and 2019. The search resulted in one comparative case series (Level III), four prospective cohort studies (Level III) and **four** case series (Level IV). From these studies, **249** patients were identified.

Conclusions: The combination of UKR and ACL reconstruction appears a safe and effective procedure providing satisfying outcomes and limited complications in selected patients with medial OA and ACL insufficiency. Further comparative studies reporting long-term outcomes are needed, as high-level studies on this topic are lacking.

Keywords: medial osteoarthritis; unicompartmental knee replacement; anterior cruciate ligament; ACL reconstruction; activity level

Level of evidence: V, Systematic review

INTRODUCTION

The treatment of unicompartmental knee osteoarthritis (OA) in young and active patients with anterior cruciate ligament (ACL) deficiency is an issue of debate **[1-4]**.

Older patients are more likely to suffer from pain related to OA, and develop secondary ACL failure as a result of the degenerative process [3]. Conversely, in younger patients, an untreated primary ACL rupture typically leads to recurrent giving-way episodes associated to posterior femoral subluxation, posteromedial compartment wear and ultimately medial OA [5].

Traditional treatment options have ranged from joint distraction [6], to high tibial osteotomy (HTO) with and without ACL reconstruction [**7, 8**], to total knee replacement (TKR) [**1**].

Bone-conserving options are preferred for younger patients with higher physical demands, and the need for reduced invasiveness, bone stock preservation, and faster recovery time, as well as improved knee kinematics had led the way to the development of a new surgical strategy.

In order to overcome the shortcomings related to TKR, recently a treatment option combining medial unicompartmental knee replacement (UKR) and ACL reconstruction has been proposed [**9-20**]**, since there is general agreement that UKR alone should not be performed in ACL-deficient knees [3].**

Although early satisfactory outcomes were reported, still limited experience exists in this field.

The purpose of our article is to report, through a systematic review of the literature, **clinical and radiographic outcomes** of UKR combined to ACL reconstruction, focusing on useful decision-making criteria guiding surgeons to the most appropriate therapeutic approach for the ACL-deficient knee in the osteoarthritic knee.

MATERIALS AND METHODS

Types of studies

In the present review only studies in English pertaining all levels of evidence reporting on subjects with medial OA and ACL deficiency undergoing UKR combined to ACL reconstruction were

considered. Date limits were set between 1990 to 2019 to allow a review of recent data. We excluded review articles and expert opinion or editorial pieces.

Search strategy

Searches were carried out using the following string on Pubmed/MEDLINE , SCOPUS and Embase: ((anterior cruciate ligament reconstruction) OR (ACL reconstruction)) AND ((unicompartmental knee replacement) OR (unicompartmental knee prosthesis) OR (unicompartmental knee arthroplasty) OR (unicondylar knee arthroplasty) OR (unicondylar knee prosthesis) OR (unicondylar knee replacement)). The Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines were used [21]. The abstracts of all hits were reviewed and duplicates were sorted out. **The full texts of the selected articles obtained were evaluated for eligibility.** References were hand screened for relevant citations to identify any articles not included in the primary search.

Data extraction

Study characteristics such as year of publication, study population, level of evidence, mean age, **male/female ratio,** follow-up duration, type of prosthesis, type of surgical intervention (either staged or combined) were extracted and collected by two reviewers, and checked by a third. An electronic database was created. Outcomes of interest included indications, clinical assessment including activity level, associated procedures, rate of complications such as revision surgery.

RESULTS

Search results

Overall, the search query yielded 1394 results. After duplicates were sorted out, 604 articles were screened for eligibility on the basis of title and abstract. Overall, 11 studies whose full-text articles were assessed for eligibility met all the inclusion criteria for this review. One article reported redundand data and one was a technical note with no reported outcomes and were therefore excluded, thus leaving 9 studies to be included in the present review

(Fig. 1). All were published between 2006 and 2019. The search resulted in one comparative case series (Level III) [**19**], four prospective cohort studies (Level III) [**9, 12, 16, 18**] and **four** case series (Level IV) [**11, 13, 17, 20**]. Average follow-up periods ranged from 2 years to 7.8 years in a long-term study. From these studies, **263** patients were identified. Table 1 provides an overview of the characteristics of the studies considered.

Indications

The indications for this type of surgical management include patients with a primary ACL tear who develop secondary medial OA **[5]**. **Only two studies [9, 12] reported which was the main complaint of the patients between medial knee pain and instability and performed one- or two-stage approach accordingly.**

Radiological assessment

OA was diagnosed pre-operatively using long-leg standing and standard radiographs; in **four** studies [**12, 13, 18, 19**] valgus stress radiographs in 20° of flexion were performed. Only in two studies magnetic resonance imaging (MRI) was performed to evaluate the knee joint pre-operatively [**17, 19**]. Post-operative standard x-rays were performed to assess positioning of the implant and presence of radiolucent lines in the majority of studies. In five studies [**11, 13, 18-20**] radiological outcomes included long-leg standing radiographs in order to compare pre- and post-operative leg alignment.

Surgical technique

In two papers [**9, 12**], a total of 29 patients underwent a two-staged procedure, while in all other patients ACL reconstruction and UKR were performed in the same sitting.

Anteroposterior laxity

Tinius et al [**13**] quantified postoperative antero-posterior laxity using Rolimeter (Aircast, Summit, NJ, USA) and reported a reduction in the maximal anterior translation to less than 5 mm in 24

patients (88.9%). The KT-1000 arthrometer (MEDmetric Corp., San Diego, CA, USA) was used in **one** of the studies considered to instrumentally assess the amount of anteroposterior dislocation [**17**]. An improvement in mean residual differential laxity, with a a side-to-side difference of 2.8 mm at the most recent follow-up was reported [**17**].

Prosthesis design

Four studies report on the implantation of mobile-bearing designs **[9, 12, 16, 18], while in other four** studies a fixed-bearing design was adopted [**11, 13, 17, 20**]. Only one retrospective case-control study comparing the outcomes of mobile bearing UKRs with those of fixed-bearing ones during combined ACL reconstruction and medial UKR did not report any statistically significant difference between different prosthesis designs regarding mid-term clinical and radiological outcomes [**19**]

Graft choice

Most studies used ipsilateral autologous hamstring autografts for ACL reconstruction [**13, 16-20**]. **Two studies** did not **discriminate** between the outcomes of the two surgical techniques in a mixed population of autologous bone-patellar tendon-bone (BPTB) and hamstring grafts [**11, 12**]. Weston-Simmons et al [**9**] did not report any statistical difference in the clinical outcomes or survival between those patients who had BPTB grafts and those who had hamstring grafts.

Complication rates

Overall, the following major complications were reported: **two** deep infections **[9, 12]**, in three cases insert dislocation of a mobile bearing occurred **[9, 18]**, in **six** cases**,** due to pain persistence **and symptomatic lateral osteoarthritis,** conversion to TKR was performed **[9, 16, 17, 20]**. Survivorship of the implant ranged from 87.5% to 100%. The highest failure rate (12.5%) was reported by Iriberri et al. [**20**]. None reported graft failures. One study reported complications arising from external meniscus tear [**20**].

DISCUSSION

Based on the data present in literature, UKR combined to ACL reconstruction appears a safe and effective procedure in the treatment of unicompartmental OA in association with ACL deficiency: satisfying outcomes and limited complications were reported, although these data should be interpreted with caution because of the low-quality evidence of the studies included.

Medial osteoarthritis in conjunction with antero-posterior laxity in middle-aged patients is still an issue of debate, as evidence lacks on whether to treat unicompartmental OA in association with ACL deficiency **[22]**.

Concerning indications, **consensus exists among surgeons that the decision whether to perform this combined procedure should rely on whether the primary issue is ACL incompetence or medial OA. Young and active subjects with an untreated ACL tear are more likely to develop secondary posteromedial OA, due to recurrent instability leading to posterior femoral subluxation [5]. In these cases, the other compartments keep their integrity, and ACL reconstruction combined to UKR could be a treatment option [12]. In contrast, in older patients suffering from primary medial OA, the ACL may be damaged as a result of the degenerative process and additional pathologic changes such as involvement of the lateral compartment and shortening of the medial collateral ligament may occur [3]. These patients are therefore not good candidate for this combined procedure and may benefit from a TKR [18]. Since this combined approach ideally suits to the young and active population, there are concerns that improved knee function may result in increased physical demands on the joint. For this reason, most surgeons agree that patients' compliance is critical and that appropriate patient selection should be taken into account in order to maximize the outcomes.**

Radiological assessment **is mandatory** to check the integrity of the lateral compartment and **some authors suggest** the use of valgus stress radiographs to assess the tension of the medial collateral ligament. **MRI studies are not performed on a regular basis, and ACL tears are mainly diagnosed clinically or with the use of diagnostic arthroscopy.**

According to our findings, selected and motivated patients affected by unicompartmental OA in conjunction with ACL deficiency may experience considerable recovery of function and stability after combined and ACL reconstruction, with favorable outcomes in this patient population with regard to subjective and objective scores. An improvement in Tegner post-operative outcome scores was reported in **four** studies **[9, 12, 16, 18], including a total of 165 patients,** thus showing that the majority of patients returned to their pre-injury activity levels.

No graft failures were reported. This may be related to the fact that most of middle-aged patients do not return to sports involving pivoting, cutting, and jumping, thus preventing the risk of re-injury. In addition **the osteoarthritic process as well as the impact of the surgical operation could have increased joint stiffness.**

Only in two papers [**9, 12**], a total of 29 patients underwent a two-staged procedure **while in all other patients ACL reconstruction and UKR were performed in the same sitting. Authors who performed two-staged procedures reserved this approach to patients for whom the main complaint was knee instability and performed ACL reconstruction first followed by UKR for persistent pain; conversely, one-staged procedure whose chosen for patients complaining about medial knee pain.**

Advantages of a combined procedure include shorter hospitalization and reduced costs without the need for two surgical procedures. Drawbacks include a more technically-demanding procedure, potential graft impingement and undersizing of the tibial base plate as well as postoperative stiffness. Clinical results do not suggest significant differences between the two approaches.

As regards the mobile- or fixed-bearing prosthesis design, the first ones are advocate to result in low wear and loosening rates although carry the drawbacks of potential inlay dislocation. However, no difference between different prosthesis designs regarding mid-term clinical and radiological outcomes was reported, as previously outlined in literature [**23**].

According to our findings, insert dislocation of a mobile bearing implant occurred in three patients [9, 18]. Fixed-bearing prostheses have been suggested to allow appropriate implant

placement and subsequently optimize ligament tension, since their technical features do not rely on natural tension in the ligaments while implanting the components [**14, 17**].

Implant survivorship ranged from 87.5% to 100%. The majority of implant failures requiring revision to TKR were due to prosthetic joint infection or symptomatic lateral osteoarthritis.

The main limit of this systematic review is that there was a considerable lack of high-level studies supporting the combination of UKR and ACL reconstruction. However, the growing body of papers may change the approach of surgeons towards the management of the young and active patient suffering from OA and ACL insufficiency.

Further comparative studies are required in order to drive the surgeons to determine the correct therapeutic approach for the patient with concomitant medial OA and ACL deficiency. There is potential for this method of treatment to become more mainstream, but further research is warranted, thus physicians' practice and expertise still represent the most useful tool in clinical practice.

CONCLUSIONS

Although technically demanding, the combination of UKR and ACL reconstruction appears a safe and effective procedure providing satisfying outcomes and limited complications in selected patients with medial OA and ACL insufficiency. The literature on this subject is limited and further comparative studies reporting long-term outcomes are needed, as high-level studies on this topic are lacking.

CONFLICT OF INTEREST STATEMENT

All authors declare that they have no conflict of interest.

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CAPTIONS TO FIGURES

Fig. 1: PRISMA flow diagram showing the number of studies identified, screened and included in the present review

Table 1. Characteristics of included studies

Author	*Year*	*Patients number*	*Level of evidence*	*Mean age (range)[SD]*	*Male/female ratio*	*Mean follow-up (range)[SD]*	*Bearing type*	*Graft type*	*Single-stage approach (%)*	*Complications (rate)*
Pandit	2006	15	III Prospective cohort study	49.8 (36-60)	13:2	2.8 (2.5-4.3) years	Mobile	3 BPTB 11 Hamstrings	4/15 (26.7%)	1 (6.7%) Infection and two-stage revision to a TKR
Krishnan	2009	9	IV Retrospective case series	56 (50–64)	5:4	24 (12–60) months	Fixed	8 BPTB 1 Hamstrings	9/9 (100%)	None
Tinius	2012	27	IV Retrospective case series	44 (38-53)	11:16	50 (9-71) months	Fixed	Hamstrings	27/27 (100%)	None
Weston-Simons	2012	51	III Prospective cohort study	51 (36-67)	40:11	60 (12-120) months	Mobile	(?) BPTB (?) Hamstrings	33/51 (64.7%)	1 (2%) Infection and two-stage revision to a TKR 1 (2%) Bearing dislocation 1 (2%) Symptomatic lateral osteoarthritis and conversion to TKR
Tian	2016	28	III Prospective cohort study	50.5 (41-60)	10:18	52 (24-96) months	Mobile	Hamstrings	28/28 (100%)	2 (7%) Bearing dislocation
Iriberri	2018	8	IV Retrospective case series	52 (42-60)	5:3	175 (117-258) months	Fixed	Hamstrings	8/8 (100%)	1 (12.5%) Symptomatic lateral osteoarthritis and conversion to TKR 1 (12.5%) external meniscus tear repair
Tecame	2019	24	III Retrospective comparative study	47.8 (41-53) 48.4 (43-54)	20:4	53 [8.3] months 42 [6.7] months	9 Mobile 15 Fixed	Hamstrings	24/24 (100%)	None
Kennedy	2019	75	III Prospective cohort study	52.6 (36-71)	59:16	6.4 (1-15) years	Mobile	Hamstrings	58/75 (76%)	3 (3.9%) revisions to TKR
Ventura	2019	12	IV Retrospective case series	54 [3.9]	8:4	7.8 (6-10) years	Fixed	Hamstrings	12/12 (100%)	1 (8.3%) Symptomatic lateral osteoarthritis

and conversion to TKR

SD: Standard deviation; BPTB: Bone-Patellar tendon-Bone; TKR: Total knee replacement

Table 2. Summary of functional and clinical outcomes utilized in included studies

Author	*Year*	*Outcome measures*	*Pre-op mean score (range)[SD]*	*Post-op mean score (range)[SD]*
Pandit	2006	OKS KSS Objective KSS Functional Tegner Activity Level	29 (17-36) 55 (25-83) 85 (65-90) 1.6 (1-3)	46 (37-48) 99 (95-100) 96 (85-100) 3.8 (3-6)
Krishnan	2009	WOMAC index of osteoarthritis OKS KSS	45 (35–52) 23.5 (20–58) 135 (64–167)	24 (21–27) 11 (10–12) 196(190- 200)
Tinius	2011	Knee Society Score KSS Objective KSS Functional	77.1 [11.6] 38.4 [10] 38.7 [8.8]	166 [12.1] 83.2 [6.8] 82.7 [8.2]
Weston-Simons	2012	OKS AKS Functional Score AKS Objective Score Tegner Activity Score	28 (16-46) 82 (45-100) 40 (25-80) 2.5 (1-5)	41 (17-48) 95 (45-100) 75 (25-95) 3.5 (1-5)
Tian	2016	OKS KSS objective KSS functional Tegner Activity Level	31 [7.1] 60.4 [7.1] 63.7 [6.5] 4.4 [1.2]	43 [4.2] 84.5 [6.3] 86.9 [5.3] 5.3 [0.8]
Iriberri	2018	KSS WOMAC index of osteoarthritis VAS	94 (62-165) 59 (3-81) 8 (6-10)	154 (102-200) 26 (1-52) 3 (0-7)
Tecame	2019	WOMAC index of osteoarthritis KSS functional KSS objective	55.8 [7.6] mobile, 59 [8.1] fixed 71.2 [7.4] mobile, 70.2 [6.4] fixed 37.3 [4.3] mobile, 38.6 [3.8] fixed	79.3 [7.3] mobile, 81.3 [7.6] fixed 86.2 [6.2] mobile, 84.7 [5.9] fixed 73.4 [9.3] mobile, 77.3 [10.5] fixed
Kennedy	2019	OKS Tegner Activity Level	29.0 [8] 2.8 [1]	41 (11-48) 3.6 (0-8)
Ventura	2019	KOOS OKS WOMAC index of osteoarthritis AKS Objective Score AKS Functional Score Mean side-to-side anterior laxity in mm	62.4 [8.1] 28.8 [10.1] 71.9 [11.5] 45 [12.9] 80 [14.2] 5.7 [1.4]	80.2 [11.7] 42.4 [8.9] 84.9 [9.3] 75 [13.5] 88 [16.2] 2.8 [0.9]

SD : Standard deviation ; KOOS: Knee Osteoarthritis Outcome Score; OKS: Oxford Knee Score; KSS: Knee Society Score; WOMAC: Western Ontario and McMaster; AKS: American Knee Society;

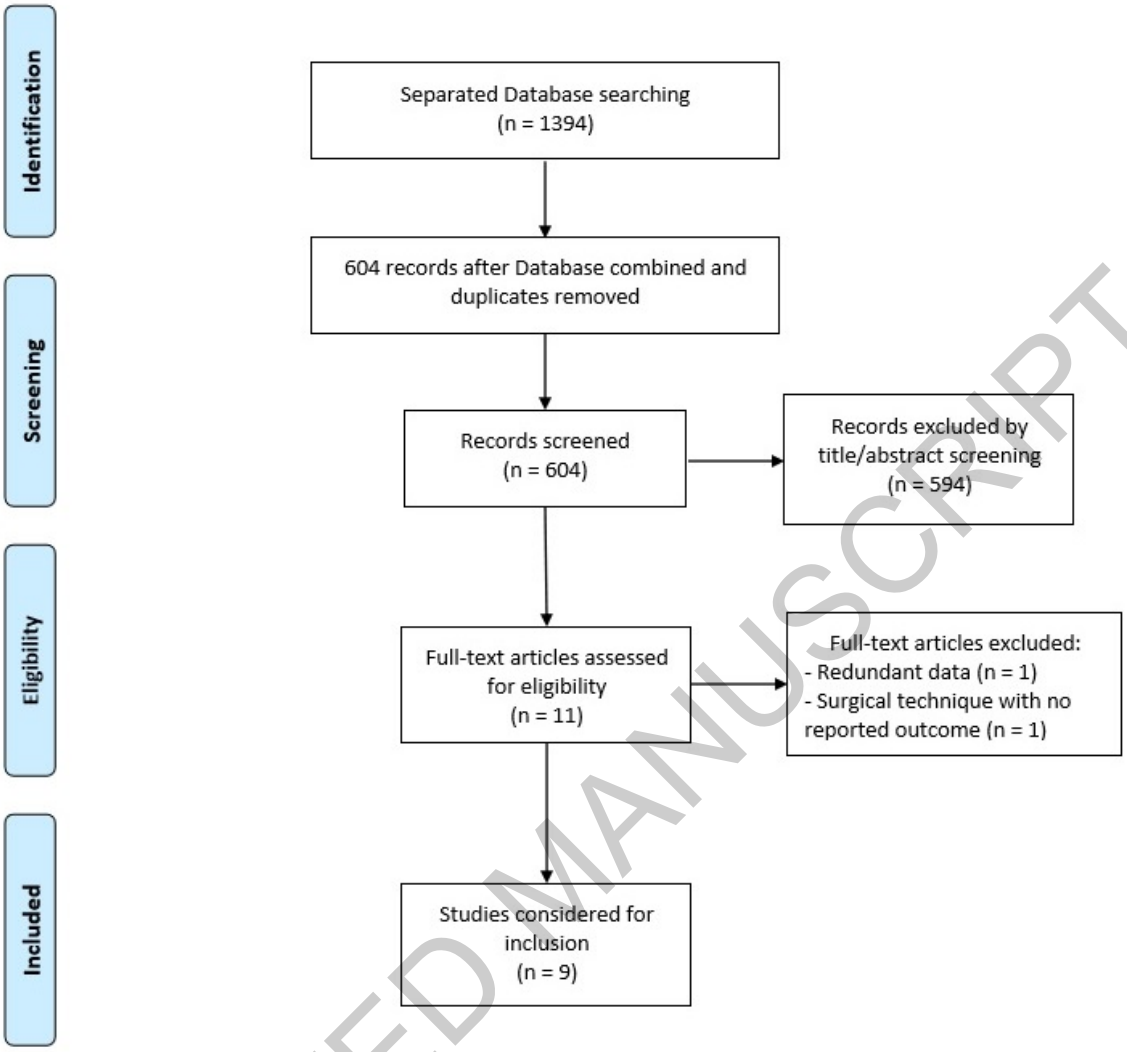

Fig 1