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Research Article

Unicompartimental Knee Arthroplasty with Simultaneous LCA Reconstruction, A Novel Technique for Selected Patients: A Systematic Review of the Literature

Gianmaria Filippo Rosa*[2], Aliekber Yapar, MD, Assoc Prof[1,2], Adhir Jain MD [3]

1. Antalya Training and Research Hospital- Antalya/ Turkey.

Orcid ID: 0000-0003-2227-21732- Helios Endo-Klinik

2. Helios Endo-Klinik.

3. Consultant Surgeon at Jain Hospital Sanawad, Pin Code 45111.

***Correspondence to:** Gianmaria Filippo Rosa, MD. IRCCS Policlinic San Martino Hospital, Genova, Italy, Orcid ID: 0009-0002-0045-1613

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Introduction

The treatment of medial knee Osteoarthritis (OA) associated with Anterior Cruciate Ligament (ACL) deficiency is still debated, especially among young and active patients.

Primary OA in an ACL-intact knee usually involves the antero-medial side of the tibial plateau and is defined as antero-medial osteoarthritis. In this situation the postero medial compartment maintains a functional medial collateral ligament (MCL) [1] as every time the knee flexes, the femur roll out of the tibial defect allowing the MCL to regain its normal length.

Different situation is seen in patients with primary ACL damage and secondary knee OA due to repeated episodes of anterior subluxation of the tibia over the femur, with a tibial cartilage wear that is typically postero-medial, allowing normal antero-medial cartilage.

As described by Thienpoint and Parvizi in a recent classification [2] in a reducible varus knee OAcan be localized either anteromedial or posteromedial. Anteromedial OA is clearly seen on anteroposterior and lateral radiographs, which show that the ACL is intact. If posteromedial osteoarthritis is present, this is suggestive for a tear of the ACL. Observing a lateral knee view radiograph at 30 ° of flexion the femoral condyle should be articulating with the mid portion of the tibial articular plateau. A more posterior articulation should indicate a posterior cartilage wear associated with ACL deficiency. The goal of any surgical treatment is to eliminate the symptoms of instability and OA pain and not compromise any future surgery with bone preservation procedures. Analyzing the literature different options are available, from Unicompartimental Knee Arthoplasty (UKA) associated or not with ACL reconstruction, High Tibial Osteotomy (HTO) with or without ACL reconstruction and finally Total Knee Arthroplasty (TKA) [3,4,5].

Clinical indications for Unicompartimental Knee Arthoplasty (UKA) are antero-medial OA in a stable knee, functionally intact lateral and femoro-patellar compartments, correctable (intra-articular) varus deformity, less than 10- 15 degrees of fixed flexion deformity, and articular flexion beyond 100 degrees. However, isolated medial UKA performed with an ACL deficient knee OA has been shown to have an intolerable rate of 21% failure at two years [6] in active patients, with majority of failures occurring due to early tibial loosening. For these reasons, in last few years ACL reconstruction combined with simultaneous medial unicompartimental knee arthroplasty (UKA) has been performed with good clinical outcomes [7,8,9].

Considering the increasing interest on this theme, the purpose of this systematic review is to summarize and compare indications, clinical outcomes, complications and rehabilitation protocols of simultaneous ACL reconstruction and UKA.

Materials and Methods

A review of the literature was conducted in a systematic manner in accordance with the PRISMA statement [10]. Studies were identified by electronically researching the literature, using the PubMed Medline, Cochrane Library and Google Scholar, to retrieve all available relevant articles using the following keywords: ((Anterior cruciate AND (arthroscopy OR ligament OR reconstruction OR surgery OR deficiency)) AND ((unicompartmental knee AND (arthroplasty OR replacement OR surgery OR osteoarthrosis)).

The studies published until August 2022 were included in this systematic review. The bibliographies of each identified article were manually reviewed in order to retrieve further potential eligible articles.

The inclusion criteria were: studies providing clinical and radiological outcomes, postoperative protocols and complications about unicompartimental knee arthroplasty associated with simultaneous ACL reconstruction; retrospective or prospective clinical studies including randomized controlled trials, nonrandomized trials, cohort studies, case-control studies and case series with a minimum follow-up of 1 year; papers in English without any restriction on publication date.

The exclusion criteria were: articles that did not provide complications, clinical or radiological outcomesand rehabilitation protocols about studies concerning isolated or staged unicompartimental knee arthroplasties or a single ACL surgery; experimental biomechanical or in vitro studies; surgical technique papers, case reports and reviews or meta-analyses.

One reviewer applied the previously determined criteria to select potentially relevant papers using a standardised method. Articles were initially identified based on title and abstract; for each citation that met the inclusion criteria, the full text was obtained and carefully reviewed. Fulltext versions of relevant trials were then obtained and evaluated. References of the identified articles were checked not to miss any further relevant articles. The Level of Evidence (LOE) of the studies was assigned based on the 2011 Oxford Centre for Evidence-based Medicine Levels of Evidence [11]. The following data, when available, were extracted from the studies: level of evidence, study methods, number of patients, age, sex, mean follow up, AO classification, type of bearing and fixation of the implant, tendon graft choice for ACL reconstruction, outcome scores, rehabilitation protocols and complications.

Results

A total 11 articles were finally included in the systematic review, all concerning UKA and simultaneous ACL reconstruction [7,8,9,12,13,15,16,17,18,19,20]. The PRISMA 2009 diagramillustrates the studies that have been identified, included and excluded as well as the reason for exclusion (Fig. 1). Most of papers were rated as level IV according to 2011 Oxford Center for Evidencebased Medicine Levels of Evidences; just two retrospective comparative studies (UKA and ACLR compared with ACL intact patients [18] and UKA mobile vs. fixed bearing and ACLR [19]) were rated level III. Tables 1 and 2 summarize data extracted from included papers.

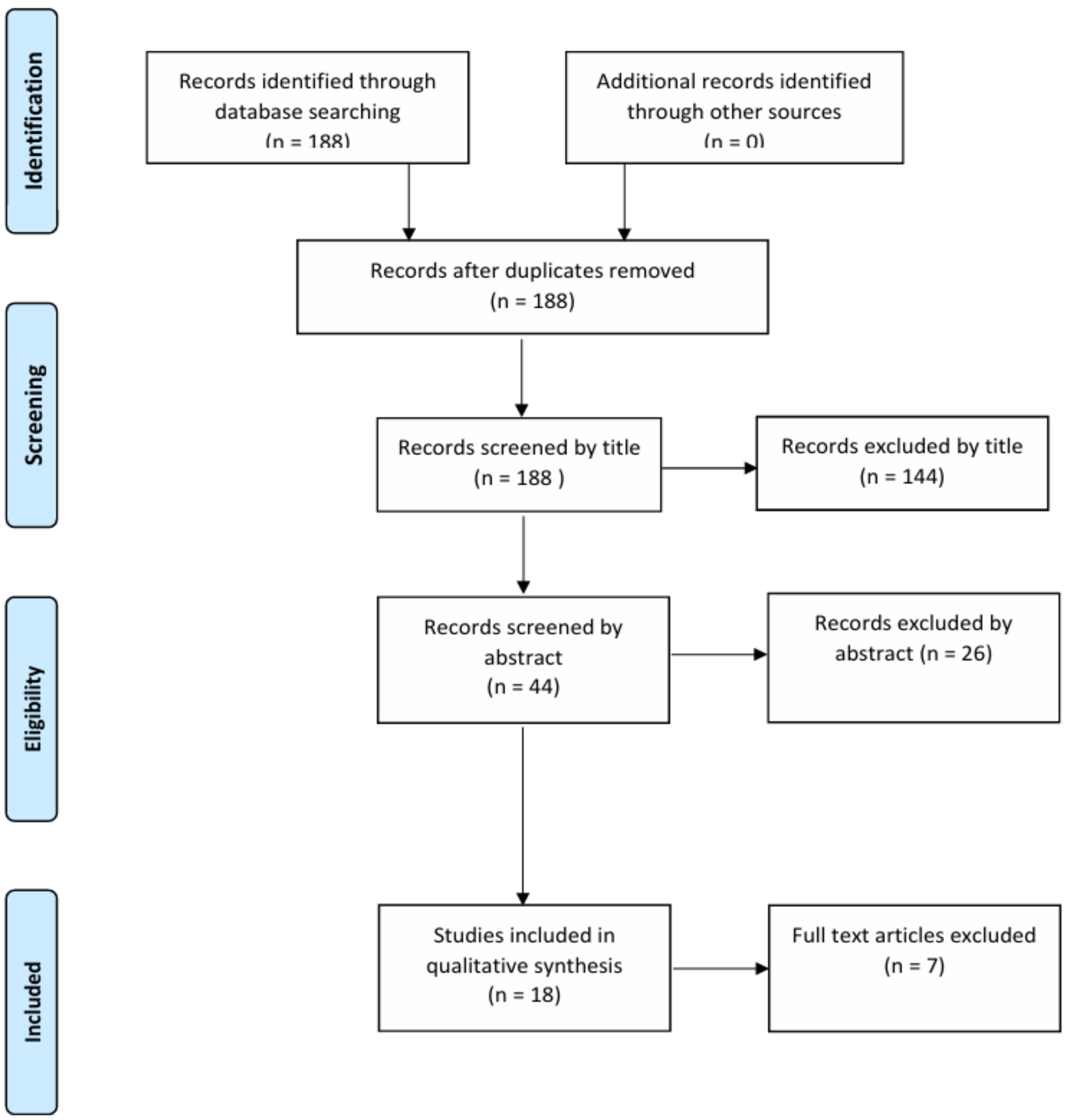

Fig. 1 The PRISMA flow diagram illustrates the studies that have been identified, included and excluded as well as the reason for exclusion.

Demographic data and Study Characteristics

All studies investigated were published between 2009 [12] and 2023 [8,9]. An overall number of 237 patients were involved. In one paper, some patients that had both unicompartimental or bicompartimental and ACL reconstruction were excluded [12]. The number of patients treated in each study varies from 7 [12] to 58 [18] with a variable follow-up from 2 years [12] to 14.6 years [17].

Between the eleven studies included, two were retrospective cohort comparative study and have been classified LOE III [18,19], the others [7,8,9,12,13,15,16,17,20] were classified LOE IV according with Oxford Centre for Evidence-based Medicine Levels of Evidence criteria [11].

OA classification

Most of patients has been evaluated and then classified as high grade medial OA. Only two Authors reported grade IV Kellgrer-Lawrence classification [7,19]. The majority of papers refear to Alback criteria to classify the OA degree. Some studies involved only Alback grade IV patients [13,20] while others included also patients complaining knee pain classified as grade II or III OA [9,16,17]. Tecame et Al [19] classified 24 young and active patients with bone-on-bone knee OA as Type IA–PMOA in accordance with the recent varus knee classification of Thienpont and Parvizi [2].

Surgical Technique

The patient is positioned supine over the operating table. Preoperative antibiotics and usual anesthetic therapy is infused. A preliminary diagnostic knee arthroscopy is carried out first to confirm the diagnosis and the correct surgical indication for Unicompartmental Knee Arthroplasty and ACL reconstruction [7,8,9,13,15,17,19,20]. Just one Author performed knee arthroscopic evaluation after ACL graft harvesting [9]. The graft choice was in most of cases a four stranded hamstrings autograft [7,8,13,15,16,17,18,19,20], while Kennedy and Krishnan et Al. used both hamstrings and bone-patellar-bone autograft [12,18]. There is no consensus about the correct timing of reaming bone tunnels for ACLR. In two studies the tunnels were prepared after the bone cuts for UKA [15,16]. Tecame et Al. performed firstly the femoral tunnel, then the bone cuts and finally the tibial tunnel [19]. Iriberri et Al. performed before UKA bone cuts and then, with trial implant positioned, they prepared tunnels for ACLR [17]. In just one study the ACLR was performed before and the UKA implantation followed [20].

Femoral tunnel has been more often drilled using a trans-tibial technique [13,15,16,20]. Iriberri reported also the out-in technique [17], while Tecame described the using of anteromedial portal for drilling femoral tunnel [19].

About the distal tibial fixation of the graft, it was generally obtained thanks to an interference screw as described in few studies [8,9,12,13,16,19,20,]. Tian et Al. used the Intrafix tibial fastener system (DePuy Mitek) [15]. Femoral fixation was variable with different techniques applied by the Authors. A simple interfernce screw was used in some patients [9,12,17]. Rigid-Fix (De Puy Mitek) femoral device was applied by Ventura and Aslan et Al. [16,20]. Trans-fix pin (Arthrex) was fixed by Tinius [13] while Jaber et Al. preferred a femoral Thightrope (Arthrex) [8]. Endobutton CL (Smith and Nephew) was finally choosen for patients treated in two studies [15,19].

In most cases, implants had cemented fixation [15,19,16,17,13,9,7,12] and fixed bearing [7,12,13,16,17]. Mobile bearing UKA is also described by different Authors [8,15,18,20,21]. According with the literature both uncemented and cemented prosthesis were used in few studies [18,20,8].

Rehabilitation Protocols

Rehabilitation protocols are described by few authors [8,12,15,16,19]. Krishnan et Al allowed full weight bearing and mobilization with the use of two crutches from the first postoperative day [12]. Other Authors agree on a partial weight bearing for two [15] or four weeks [8,16,19]. Almost all studies agree on a quick restoration of range of motion (ROM), quadriceps exercises and stretching after surgery. Proprioception exercises are allowed from one month after surgery [8,12,16,19]. Tecame recommended the use of a brace without limitations of ROM and avoided knee flexion over 90 ° in early rehabilitation phase [19]. Jaber et Al. suggested starting jogging from 3 months postoperatively and allowed non-contact sports from 6 months [8].

Outcomes Score

In our review process, clinical outcomes presented in each study refear to different validated score. Especially Oxford Knee Score (OKS) [7,12,1415,16,18,20] and Tegner Activity Scale Level (TAS) [7,8,9,15,18] were the most used by different Authors. Knee Society Score (KSS) was applied in five papers [12,13,15,16,19], while the Western Ontario and Mc Master Score (WOMAC) has been evaluated in four studies [12,16,17,19]. Knee Osteoarthritis Outcomes Score (KOOS) was reported in two papers [16,20]. The EuroQol-visual analogue scales (EQ-VAS) [20] and Forgotten Joint Score (FJS) were reported respectively just by one Author. Furthermore, Visual Analogue Scale (VAS) for pain was reported in few studies [7,8,17].

For the lower limb alignment evalutation a full weight bearing radiograph was performed in several studies [13,15,19,20]. In almost all studies, radiological follow up was analyzed on a knee weight bearing x-ray with standard anteroposterior (AP) and lateral projections, in order to define implant posizioning, tibial slope and any eventual presence of radiolucency lines around the implants. The posterior slope of the tibial component was defined as an angle between the posterior inclination of the tibial implant and a line perpendicular to the posterior tibial cortex as described by Hernigou and Deschamps in the literature [22].

Anterior tibial translation (ATT) was assessed as a sign of ACL deficiency: two lines were drawn tangential to the posterior border of the upper tibia and the femoral condyle, the distance between both lines was considered as ATT (positive values for anterior tibial subluxation) [17,23]. Any loosening of the components was evaluated with radiolucencies lines analyses and were judged as physiological or pathological according to criteria expressed by Goodfellow et al. [15,16,24] or Tibrewal et Al. [17,25].

Krishnan et Al. [12] implanted a fixed bearing UKA in a group of 9 patients, with a simultaneous ACLR. Two patients were excluded beacause of bilateral replacement and one for a lateral compartment knee arthroplasty. The average preoperative deformity was 8° of varus from the mechanical axis. The average postoperative alignment was 2° of varus, for an average correction of 6°. The medium arc of flexion was 119° (range 85° to 135°) preoperatively and 125° at a mean follow up of two years. KSS,OKS and WOMAC improvements were significant.

Few years later in 2012 Tinius et Al. [13] published their results in a population of 27 patients, using a fixed bearing cemented implant. At a mean 4.2 years follow up the KSS improved significantly from 77 ± 11.6 points prior to surgery to 166 ± 12.1 points after surgery (P\0.01). Twenty-four patients presented antero-posterior translation of less than 5 mm after surgery. The leg alignment showed 2.7 ± 1 of varus deformity prior to surgery and 3.9 ± 0.5 of valgus after surgery. The posterior slope of the tibial component was 3.7 ± 1.6. A significant correlation was found between the posterior slope of the tibial component and the range of motion ($r = 0.40$, $P = 0.04$) which improves with the increasing slope of the tibial component.

Tian et Al [15] implanted a mobile bearing UKA in 28 patients with a combined ACLR. The improvements in TAS, KSS, and OKA were statistically significant ($p<0.05$) at a mean follow up of 4.3 years. The leg alignment showed 3.1 ± 0.6° of varus deformity prior to surgery and 4.0 ± 0.7° of valgus after surgery. The posterior slope of the tibial component was 3.9 ± 1.2°. The mean ROM of the operated knee in sagittal plane at the last FU was 123.5 ± 2.8°. These data confirm that higher tibial slopes are correlated with more range of motion. In 2019 Iriberri et Al. published their results of 8 patients treated with a fixed bearing cemented implant and four stranded hamstrings ACLR with a significant 14.5 years follow up [17]. . Patients were very satisfed for the evolution of their knees, with a mean of 8.8 points (4–10) of personal satisfaction.

Clinical score sas WOMAC, KSS and VAS improved from a preoperative value of 94,59 and 8 respectively to a postoperative value of 154,26 and 3 (p<0.01). Mean range of motion increased from 110° (60–130) to 120° (110–130). Finally, ACLR t did not produce any statistically signifcant correction of ATT after surgery (p=0.37).

Kennedy et Al. [18] reported the largest cohort of patients treated with simultaneous UKA and ACLR reconstruction. They compared outcomes between patients treated younger than 55 at surgery and those older, those with follow-up greater than 10 years and those with cemented or cementless UKA. Among 75 patients, only 58 (76%) performed simultaneous surgery and were included in our review. At most recent follow-up, OKS was 41.0 (range 11 to 48), and TAS 3.6 (0 to 8). The %, 10 and 15 year survival estimates were 97% (95% confidence interval [CI] 93–100), 92% (83–100), and 92% (83–100). There was no difference in functional scores or implant survival in younger patients, those with long-term follow-up >10 years or those with cementless fixation. Tecame et Al. divided 24 patients into two groups based on the type of implant, mobile or fixed bearing. This retrospective comparative study showed no significant difference in WOMAC index and KSS both objective and functional between groups at the last follow-up (KSS objective 73.4 ± 9.3 vs 77.3 ± 10.5; KSS functional 86.2 ± 6.2 vs 84.7 ± 5.9; WOMAC 79.3 ± 7.3 vs 81.3 ± 7.6 for Group 1 and 2, respectively). The X-ray analyses showed a significant change in terms of lower limb alignment in both groups, passing from a varus of 4.1° ± 1.05 to 2.5° ± 1.8 and from a varus of 4.4° ± 1.3 to 2.7° ± 0.9 for Group 1 and 2, respectively [19]. In 2020 Ventura et Al. found a significant reduction of anteroposterior translation from a preoperative laxity of 5.7mm to 2.8 after surgery (p < 0.001). Their retrospective evaluation of 12 patients treated with a fixed bearing cemeted UKA with a mean follow up of 7.8 years, showed also improvements in KOOS score, OKS, WOMAC and the AKSS increased from preoperative status, showing a statistically significant difference (p < 0.001) [16].

Furthermore, Aslan et Al. studied the outcomes of a cohort of 12 patients with an average follow up of 45.7 months. They were treated with a mobile bearing implant and both cemented and uncemented fixation. The leg alignment showed 3.6 degrees ± 1 of varus deformity before surgery and 2.6 degrees ± 1 of valgus after surgery. The OKS and KOOS pain, symptom, daily life, and quality of life, EQ-5D-3L, and EQ-VAS improved significantly at the mean follow up (p < 0.001) [20].

More recently, Krishnan et Al. published their results above 24 patients underwent simultaneous combined ACLR and medial fixed bearing UKA with a mean follow up of 5.1 years. In 5 cases has been performed arevision ACL reconstruction, four underwent patella tendon graft and one had a tibialis anterior allograft. Significant improvements in knee pain score VAS ($P < 0.001$), OKS ($P < 0.001$), Lysholm score ($P < 0.001$) and TAS ($P < 0.001$) were seen with this combined approach with all patients returning to sport [7].

In 2022 Jaber et Al. described a combined treatment with mobile bearing UKA and ACLR using tendon hamstring in 23 patients; in four cases the implant was uncemented. The mean follow up was 10 years (range 6-14.5). At the final assessment VAS, TAS and Lysholm score improved significantly; OKS and IKDC 2000 showed excellent results. The implant survival rate was 91,4% at 14.5 years.Full knee extension was reached by 21 patients while just 2 patients had a 5° knee extension deficit. The return to sport rate was 100% [8].

The most recent study was published by Fossey et Al. [9] with a retrospective single centre study of ten patients operated using a cemented fixed bearing UKA (2 patients with lateral implants were excluded in our review) inserted with the assistance of an image-free robotic-assisted system. At the mean follow-up of 45 months ± 13 months, post-operative IKS knee and function score were respectively 96 ± 4.5 and 93 ± 8.2, TAS was 4.5 ± 1.4 and 90% of patients returned to sport.

Complications

Based on the collected data, complications occurred in twelve patients (5.1%) considering the longer follow up; eleven of these, required secondary surgery. Considering the complication rate at five years post-surgery, it is around 3.8 % of cases. The most common complication described in literature was the progression of osteoarthritis in the lateral compartment of the knee. In few cases, patients were treated with conversion to total knee arthroplasty (TKA) as described by Ventura et Al, Kennedy and Iriberri et Al. [16, 17, 18]. Jaber et Al.[8] reported the same complication but with a longer conversion time, around nine ten years. Tian et Al [15] had two patients with a mobile bearing dislocation that required a second surgery with a ticker inlay replacement. Three patients (two diabetic) were treated for deep infection secondary to ACLR and UKA with a two stage revision and TKA conversion [14, 18,21]. Fossey et Al. performed two arthrolysis under arthroscopy for stiffness at two and three months after surgery [9]. Just one patient had an intraoperative, undisplaced anterior cortex fracture of the medial tibial plateau which required no further supplementary fixation. He was treated with touch weight bearing for six weeks postoperatively [7]. Another case of iatrogenic lesion in described by Kurien et Al. in a patient with Grade 2 injury to the medial collateral ligament that was managed in a hinge knee brace 0-90 degrees for 6 weeks postoperatively [7].

Loosening of the tibial component has been investigated with radiolucent lines, according with Goodfellow criteria [24]. Tinius et Al. [13] reported different cases of 0.5 mm lines in nine patients, in three patients lines around 1 mm of tickness and one case of 1.5mm. Four patients presented radiolucent lines on the femoral site. Tecame et Al. described similar data about radiolucency lines without any secondary surgery [19]. According with the literature, no pathological lines were founded and the mean follow up in each study.

Discussion

The best surgical treatment and management for medial knee osteoarthritis (OA) with anterior cruciate ligament (ACL) deficiency is still controversial. Knee biomechanical changes as increased anterior translation of the tibia, medialisation of the centre of rotation and alterations between the lateral femoral condyle and tibial plateau (pivot shift), progressively involves into OA development. At the same time, primary OA progressively leads to secondary ACL instability as well as shortening of the medial collateral ligament (MCL) and gradual damage to the remaining knee compartments [8,26]. Different studies have demonstrated that cartilage and meniscal injuries requiring surgical treatment are the most important risk factors for developing knee OA [27,28]. The most recent literature describe different surgical techniques for the treatment of medial knee osteoarthritis secondary to an ACL defiency: unicompartmental knee arthroplasty (UKA) with or without ACL reconstruction (ACLR), high tibial osteotomy (HTO) with or witout ACLR and TKA [3,4]. UKA combined with ACLR performed in one-stage is a viable option in young and active patients. This procedure has several advantages when compared with TKA, among all bone stock preservation, less blood loss and better knee kinematics [29]. For sure, this is an high demanding surgery technique and should be performed by experienced surgeons after a long learning curve and an accurate selection of patients.

Despite HTO and UKA have been considered as valid treatment options for the management of medial OA secondary to ACL deficiency, the philosophy behind each technique is quite different, and there is still lack of consensus in the literature on which technique provides the best outcomes for specific patients [31]. Moreover, while HTO can be performed either with or without ACL reconstruction, it is proven that an isolated UKA associated with an ACL deficient monocompartmental knee OA has been shown to have a not negligible rate of 21% failure at two years [6] with early tibial loosening. Furthermore, according with Mancuso et Al. [4] the revision rate following both HTO and UKA is significantly lower when ACL reconstruction is performed, compared to when it is not.

TKA remains the best and the most safe procedure for elderly and low demanding patients with severe OA and deformity [3,30], associated with a low revision rate.

All Authors agree that patients with ACL injury complaining knee instability and isolated medial compartment pain are the best candidates for this procedure. According with our results, all clinical and outcome scores improved significantly at the mean follow up, without any differences regarding the type of fixation and implant characteristics. There was not any statistically significant variable in clinical outcomes among male and female patients. The largest cohort was described by Kennedy et Al. [18] with 58 patients included, while Iriberri et Al. analized the longest mean follow up at 14.5 years with an overall complication rate of 3.95 % [17].

The overall complication rate was 3.8 % at five years and 5.1 % over the ten years. The main cause of revision was the progression of OA in the lateral compartment that required a secondary surgery with a TKA implantation. Just one patient had an intraoperative undisplaced anterior cortex fracture of the medial tibial plateau which has been treated with touch weight bearing for six weeks [7]. No pathological radiolucency lines were founded and the mean follow up in each study.

The study conducted by Fossey et Al. is the only one which reports a robotic assisted technique: achieving a perfect balancing may reduce the incidence of liner dislocation and instability, therefore robotically assisted surgery aids this goal by providing anticipated gaps with implant panning [9]. The importance of functional tensioning of ACL and collateral ligaments for successful outcomes with mobile-bearing UKA is confirmed by Tian et Al. [16]; in their study they reported a 7% rate of mobile bearing dislocations, treated with a ticker mobile inlay.

In this review, only patients undergoing simultaneous ACLR and UKA were included. Indeed, previous papers in the literature studied heterogeneous groups of patients underwent staged and simultaneous surgery, providing data that do not allow a significative assessment. Among these, Pandit et Al. combined reconstruction of the anterior cruciate ligament with UKA in 15 patients (ACLR group) and compared them with 15 patients who had undergone UKA with an intact anterior cruciate ligament (ACLI group). The clinical and radiological outcomes at a minimum of 2.5 years were better for the ACLR group [21]. Weston Simons et Al [14] performed a retrospective evalutation of 52 patients divided into subgroups according to age and type of surgery (staged or simultaneous) and reported no significant differences in clinical outcomes or implant survival between these groups. However, these papers were not suitable for the inclusion in our review because of the heterogeneity of surgical and staged procedures and unclear subgroups demographic data.

To our knowledge, this is the most updated systematic review that analyses the results of UKA associated with ACLR. Ouranalysis is predominately based on level IV studies, and affected by poor quality evaluation, high amount of biases and methodological inaccuracies. Furthermore, the heterogeneity of the outcome measures, the differences in follow-up periods and the design or fixation of the implants, did not allow grouping the results nor a quantitative analysis. Despite these limitations, outcomes are encouraging for the future.

Conclusion

Simultaneous UKA and ACLR in indicated in high demanding patients with knee instability and medial unicompatimental OA. The examined studies provide encouraging clinical and radiological short-to-mid-term outcomes. Patients' selection and the correct surgical indication in essential to obtain a good clinical result. In conclusion, we consider this innovative technique as a safe procedure. We strongly advocate further high-quality log-term studies to better clarify complications, clinical and radiological results of this promising technique.

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