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Excellent outcomes with combined single stage Physica ZUK medial unicompartment knee replacement and anterior cruciate ligament reconstruction results in young, active patients with instability and osteoarthritis with a mean follow up of 5 years

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ABSTRACT

Background (including the aim of the study): Young and more active patients with medial compartment osteoarthritis (OA) in conjunction with anterior cruciate ligament (ACL) deficiency are difficult to treat. The aim of this study was to explore the outcomes of combined fixed bearing Physica ZUK medial unicompartmental knee replacement (UKR) (Lima Corporate, Udine Italy) with ACL reconstruction for patients presenting with isolated medial compartment OA and symptomatic ACL deficiency.

Methods: Patients who underwent simultaneous single stage ACL reconstruction and medial UKR between 2012 and 2020 by a single surgeon (GG) were included. Preoperative outcome measures including Lysholm, Tegner, Oxford Knee Score and VAS pain score were evaluated and were repeated postoperatively at the most recent follow up appointment.

Results: Twenty four patients underwent simultaneous combined ACL and ZUK Medial UKR with a mean follow up of 5.1 years. Significant improvements in Lysholm ($p < 0.001$), Tegner ($p < 0.001$), Oxford Knee Score ($p < 0.001$) and VAS pain scores ($p < 0.001$) were seen with this combined approach with all patients returning to sport. Two patients had a minor peri-operative complication, which was treated conservatively. There were no revision procedures, and no evidence of implant loosening, however one patient had deceased due to an unrelated illness.

Conclusion: UKR combined with ACL reconstruction can be an effective treatment option for selected patients suffering from medial unicompartmental knee osteoarthritis and symptomatic ACL deficiency. This allowed active patients to return to sports, addressing both instability and OA pain in a specific patient population.

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1. Introduction

Patients with a primary Anterior Cruciate Ligament (ACL) injury who later develop symptomatic secondary medial knee OA are generally young, active and keen to return to sport, however treatment of these patients whose instability and pain is refractory to non-operative treatments remains a challenge. Studies have identified that concomitant chondral damage or meniscal injury requiring meniscectomy are significant predictors for further progression of OA after ACL injury [1,2]. In medial compartment OA in ACL-intact knees, the anteromedial region of the tibial plateau is the most affected region to undergo cartilage degradation, however in an ACL-deficient knees, the ACL laxity results in recurrent posterior femoral subluxation leading to more progressive posteromedial wear in the medial tibial plateau [3,4]. Varus deformity is more likely in ACL deficient knees which can further alter the normal biomechanics of the joint resulting in increased pain, reduced range of movement and cessation of high level or recreational sporting activity [2].

Due to the younger age and higher activity levels seen in these specific patients, 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 such as unicompartmental knee replacement (UKR) with simultaneous ACL reconstruction or high tibial osteotomy (HTO) with ACL reconstruction the preferred option before Total Knee Replacement (TKR) surgery [5–7]. Advantages of UKR over TKR are well published and include preservation of bone stock [8], lower risk of infection, thromboembolic events and mortality [9], less invasive surgery, lower risk of medical complications, shorter hospital stay, better range of movement and faster recovery [10]. UKR has also been recently shown to be more cost effective than TKR surgery [11] and has superior patient reported outcome scores compared to TKR surgery [12–14].

A systematic review has highlighted that although combined HTO with ACL reconstruction has a comparable survivorship to UKR and ACL reconstruction, HTO and ACL reconstruction has significantly higher rate of complications compared to combined ACL and UKR (21.1% vs 2.8%) [15]. However, HTO can be a very powerful corrective tool for patients with instability due to ACL deficiency, medial compartment osteoarthritis and an increased sagittal plane posterior tibia slope. Recent research has identified that increased posterior tibial slopes > 12° is directly correlated with an increased anterior tibial translation predisposing patient to ACL injury and increased graft failure after ACL reconstruction [16]. Arun *et al* performed a retrospective study on 30 patients undergoing simultaneous HTO and ACL reconstruction and found that decreasing the posterior tibial slope by $\geq 5°$ compared to the preoperative values resulted in significantly better knee functional scores after HTO and ACL reconstruction (IKDC and Lysholm scores) in young patients with ACL deficiency and medial compartment knee OA with a mean follow up of 6.23 years [17].

The majority of published series of ACL and UKR have used a mobile bearing design with a paucity of studies assessing the outcome of a fixed bearing UKR [18,19]. A retrospective small cohort study comparing outcomes of 2 groups of patients who underwent UKR and ACL reconstruction for medial OA; one group with a mobile bearing design (N = 9) and the other group using a fixed bearing UKR (N = 14) showed no significant difference in WOMAC, Knee Society score or implant loosening between the two groups at the most recent clinical follow up [19]. A recent study has shown excellent survivorship of the fixed bearing medial Physica ZUK UKR (97.9%, 95% CI 95.6–99.0%) at 12 years [20]. The aim of this study was to explore the outcomes of combined single stage procedure using the fixed bearing Physica ZUK medial UKR (Lima Corporate, Udine Italy) with simultaneous ACL reconstruction for active patients presenting with isolated medial compartment OA and symptomatic ACL deficiency.

2. Methods

From July 2008 to September 2019, 24 patients with isolated medial compartment knee osteoarthritis (OA) with symptomatic ACL deficiency underwent single stage combined arthroscopic ACL reconstruction and fixed bearing Physica ZUK medial unicompartment knee replacement surgery (Lima Orthopaedics Ltd) by a single experienced senior surgeon in a high volume Orthopaedic Unit in Derby, United Kingdom. The study was conducted upon approval from the local audit office at Royal Derby Hospital NHS Trust who approved this retrospective service evaluation project, therefore ethics approval was not required. Written informed consent was obtained. All patients involved in the study were young, active with symptomatic radiological Kellgren Lawrence Grade IV medial compartment OA with ACL deficient knees (Figure 1). Five out of the 24 patients had failure of their primary ACL reconstruction and underwent revision ACL reconstruction combined with medial UKR surgery.

ACL deficiency was assessed clinically using the Anterior drawer test, Lachman test and Pivot shift test and confirmed with MRI analysis which also detected any associated cartilage or meniscal damage within the joint prior to surgery. Preoperative radiographs including anterior-posterior (AP), lateral weightbearing and skyline axial views of the patella were routinely performed in all patients. Preservation of cartilage by radiological joint space assessment in the lateral and patellofemoral compartments was conducted using weightbearing plain radiographs and MRI (Figure 1).

All patients included in this consecutive series met the following inclusion criteria: isolated medial compartment knee OA, symptomatic ACL instability due to deficiency, fixed flexion deformity of < 10°, reducible varus deformity of < 10°, non-inflammatory arthritis and no lateral joint line or patellofemoral pain.

All 24 patients received the fixed bearing Physica ZUK (Lima Corporate, Udine Italy). Ipsilateral hamstring tendon grafts were selected for all primary ACL reconstruction in our series (Figure 1).

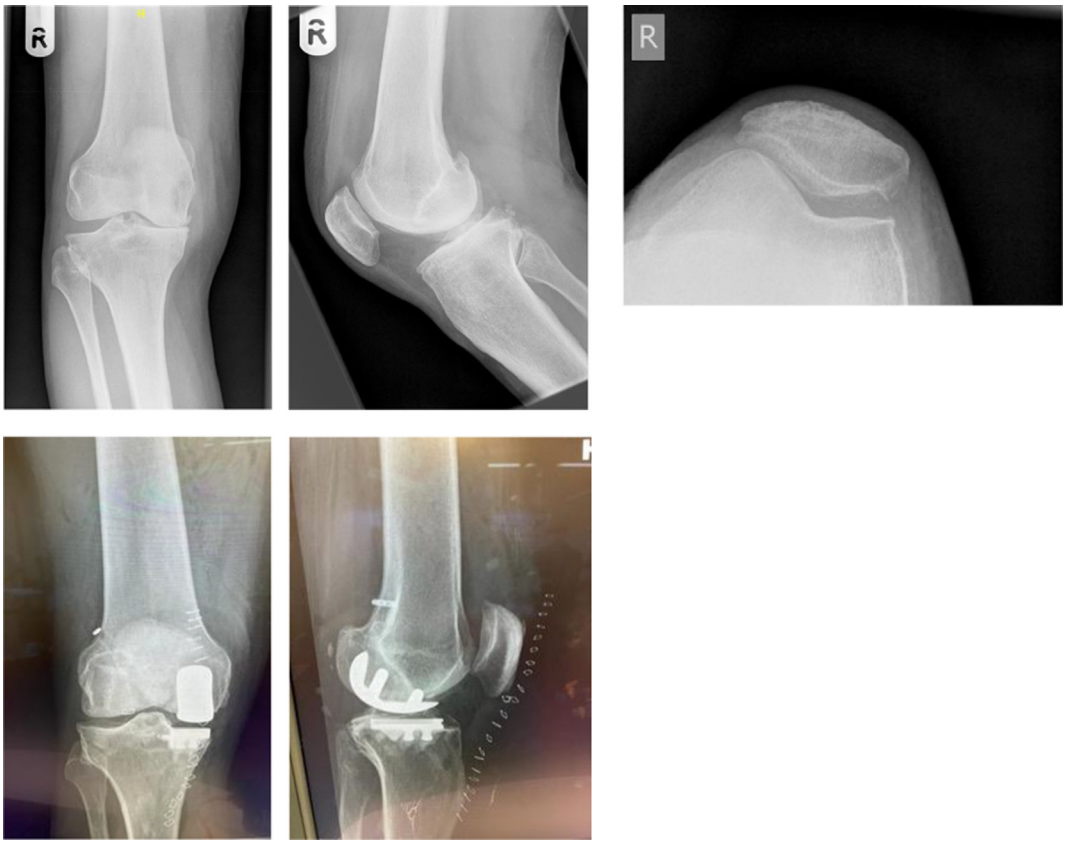

Figure 1. Preoperative radiographs – AP, Lateral and Skyline view showing severe Kellgren-Lawrence Medial compartment OA with preservation of the lateral and patellofemoral joint. Postoperative Radiographs showing Hamstring ACL reconstruction and fixed bearing Physica ZUK Medial Unicompartmental Knee Replacement.

For the 5 revision ACL reconstruction patients, four underwent patella tendon ACL reconstruction and one had a tibialis anterior allograft. Routine objective assessments undertaken in our orthopaedic department for patients undergoing joint replacement and ligament reconstruction were recorded preoperatively for all patients including the Oxford Knee Score, Visual Analogue knee pain score Lysholm score, Tegner score. The same objective outcome scores were repeated at the most recent follow up clinic up. The patient reported outcome scores and the radiological and clinical assessment of all patients were analysed by three fellowship trained orthopaedic surgeons who were blinded to the study and not involved in any of the operative cases.

The data were analysed using Prism 8.0 (GraphPad, La Jolla, CA). Data were evaluated to determine whether they met the assumption of normality using the D'Agostino-Pearson omnibus normality test. Parametric data were presented as the mean and SD with median and interquartile ranges being expressed for data that was nonparametric. The Oxford Knee Scores, Lysholm Scores, and VAS Knee pain scores pre and post-surgery were found to not be normally distributed therefore the Wilcoxon's signed ranks test was used to analysis the data. The Tegner scores pre and post ACL/UKR were normally distributed, therefore the Paired T-Test was used for this analysis.

Table 1
Pre and Postoperative Scores after combined ACL-ZUK Medial Unicompartment Knee Replacement Scores. Wilcoxen Signed Ranks Test* (median and IQR) for non-parametric data, Paired t-test (median and SD) $^{+}$ for parametric data. $p < 0.05$ considered significant.

	Preoperative	Postoperative	
Oxford Knee Score	20.0 (18–23)	46 (44–47)	$p < 0.0001^{*}$
Lysolm Score	26 (20–34)	92 (90–96)	$p < 0.0001^{*}$
Tegner Score	2.04 (0.71)	3.96 (0.98)	$p < 0.0001^{+}$
VAS Pain Score (0–10)	6.00 (4–6)	0 (0–0)	$p < 0.0001^{*}$

Differences with a P value < 0.05 were considered statistically significant. In Table 1, data is presented as mean and SD for parametric data and median and interquartile range for non-parametric data.

2.1. Operative technique

The patient is positioned supine. Preoperative antibiotics and tranexamic acid are given as per a standard Unicompartmental knee replacement. A thigh tourniquet is applied. A brief diagnostic arthroscopy is carried out first to confirm suitability for a Unicompartmental Knee Replacement and ACL deficiency.

The hamstring or patellar tendon grafts are then harvested through a paramedian incision which can later be extended (incorporating the medial arthroscopy portal) for the Unicompartmental Knee Replacement. This allows the surgeon to determine the diameter of the graft as this is needed for the next stage of the procedure. The next part of the procedure involves arthroscopic placement of the femoral tunnel through the medial portal. The tunnel is drilled to the same diameter as the graft.

The desired position of the tibial tunnel is then clearly marked arthroscopically using an arthro-wand, but the tunnel is not drilled at this stage.

The paramedian incision is then extended to the desired length depending on surgeon's preference. We routinely use a minimally invasive procedure for the Unicompartmental Knee Replacement. An open notchplasty is then carried out. This is done routinely so that the sagittal tibial cut is taken away from the midline, allowing for adequate room for the tibial tunnel. Usually a 3–5 mm notch pasty is sufficient. This often results in a slightly smaller sized tibial component compared to the femoral component, but as the ZUK is a fixed bearing prosthesis with a flat tibial insert, any tibial size can be used for any given femoral size. A standard medial Unicompartmental Knee Replacement is then carried out. The surgeon can use the tibial mark to ensure that the sagittal tibial cut is well away from the future tibial tunnel. The components are cemented into place.

The tibial tunnel is then drilled with the starting point just next to the tibial tuberosity. This avoids conflict of the tunnel with the keel of the tibial component. (In principle, the tibial tunnel could be drilled with a starting point lateral to the tibial tuberosity as the femoral tunnel is independent from the placement of the tibial tunnel, but in practice, this has never been necessary).

We recommend drilling the tibial tunnel under arthroscopic vision (using the knee replacement incision) as the surgeon will be more familiar with an arthroscopic view than a direct view of the tibial footprint. Graft passage is then completed in a standard fashion and the graft is secured in its tunnels in the surgeon's preferred fashion.

2.2. Postoperative rehabilitation

Postoperative rehabilitation was carried out as per a standard UKR in the first two months following UKR. No specific ACL rehabilitation protocol was used for the ACL reconstruction. Rehabilitation was subsequently tailored to the patient's specific needs in respect to return to some form of sports activity.

3. Results

All 24 patients underwent combined single stage ACL reconstruction and Physica ZUK medial UKR however one patient had died at the time of the most recent follow up due to an unrelated illness. The remaining twenty three patients completed the follow up assessment. The mean age of the patients was 48.8 years (range 38.3–71.0 years) with sixteen being male and 8 female and the mean +/- [SD] BMI for all patients was 24.1 +/- [2.6]. The mean follow up was 5.1 years (range 1.3–12.8 years). For the 5 revision ACL cases, 1 patients had a failed Gortex ACL graft, 1 had a failed Carbon fibre graft and the remaining three had failed hamstring grafts that were revised. Four of the five revision cases were revised with a patella tendon ACL graft and the final case had a tibialis anterior allograft.

For all the hamstring ACL reconstructions the grafts harvested were between 8–10 mm in diameter. The revision cases that used a bone patella tendon autograft the graft diameter was 10 mm and for the allograft case the diameter of graft implanted used was 9 mm. The arthroscopy findings demonstrated severe Grade IV changes in the medial compartment in all cases with only 2 out the 23 cases having mild arthritic changes (Grade I) in the lateral compartment. There were no lateral meniscal tears but in one patient mild chondrocalcinosis was seen within in the lateral meniscus. Three cases had either Grade I or II changes in the medial patella facet. No cases had significant end stage OA in either the lateral or patellofemoral joint that required conversion to TKR.

Significant improvements in knee pain VAS scores $P < 0.001$, knee function-Oxford knee Score $P < 0.001$, knee Stability, Lysholm score; $P < 0.001$ and return to Sport: Tegner Score, $P < 0.001$ were seen.

(Table 1). One patient had an undisplaced anterior cortex fracture of the medial tibial plateau at the time of surgery which required no further supplementary fixation and the patient was asked to touch weight bear on that limb for six weeks postoperatively. Another patient suffered an iatrogenic Grade 2 injury to the medial collateral ligament intraoperatively and was treated in a hinge knee brace 0-90° for 6 weeks postoperatively. Both patients continued to make an excellent recovery with no longer term disability, pain or reduced range of movement. There were no patients that suffered an infection of the joint,

thrombosis, aseptic loosening or dislocation of the bearing surface. At the last follow up there were no patients that had suffered component subsidence, pathological radiolucency or instability and no patients had clinical or radiological progression of OA in the patellofemoral or lateral compartments that required any intervention.

3.1. Return to sports

This study has shown that single-stage combined ACL reconstruction and UKR can significantly improve patient's knee stability, pain and therefore confidence when performing sports allowing patients to return to a higher level of sporting activity following surgery as shown by their improved Tegner scores (Table 1). Six patients returned to cycling (26.1%), five to swimming (21.7%), four to tennis (17.4%), three returning to the gym (13%), two returned to football (8.7%) and skiing (8.7) and one to recreational running (4.3%).

4. Discussion

This study has demonstrated that combined single stage Physica ZUK medial unicompartmental knee replacement and ACL reconstruction is an effective surgical treatment for active patients with isolated medial OA and knee instability due to ACL deficiency. Secondly, the clinical and functional results in our study are similar or superior compared to other studies where patients underwent similar procedures with different implants. At the most recent follow up there were no radiolucent lines indicative of implant loosening or failure on the radiographs and no patient had underwent revision surgery for either symptomatic progression of OA in other knee compartments or re rupture of ACL graft.

Though technically challenging, this approach can significantly reduce knee pain, improve overall knee function, improve knee stability, preserve bone stock and importantly, allow active adults active adults who are functionally demanding to return to sporting activities.

This study is the largest series of a single stage combined ACL and medial unicompartment knee replacement using the same fixed bearing implant in all cases and the first to report the outcomes using the Physica ZUK medial UKR (Lima Corporate, Udine Italy) previously known as the Zimmer Unicompartmental Knee (ZUK- Zimmer-Biomet, Warsaw Indiana, USA).

Our results are comparable to others in the literature. Tian *et al* analysed 28 patients who underwent combined UKR and ACL reconstruction using the Oxford mobile bearing UKR. There was a 7% complication rate in this series with two patients suffering mobile bearing dislocations requiring exchange of the polyethylene for a larger bearing. There was mean follow up (52 +/- 8 months) and the patient reported outcomes were very similar to our results with significant improvement in Oxford Knee Score (pre 31 +/- 7.1, post 43 +/- 4.2) and Tegner Score (pre 4.4 +/- 1.2, post 5.3 +/- 0.8) [21]. Kennedy *et al* reported the results of 76 patients who underwent UKR with staged or simultaneous ACLR and compared the findings to a cohort of ACL intact patients who underwent UKR using the mobile bearing Oxford Unicompartmental Knee Replacement (Zimmer-Biomet, Warsaw Indiana, USA). There were no differences in functional scores or implant survival in those patients that underwent combined UKR and ACLR compared to ACL intact patients that underwent UKR alone. The authors concluded that UKR and ACLR procedures outcomes that are comparable to UKR in ACL intact knees at long term follow up [22]. Ventura *et al* retrospectively reported the outcome of 14 patients with ACL deficiency and medial OA who underwent fixed bearing combined ACLR and UKR with a mean follow up of 26.7 months/ Knee Injury and Osteoarthritis Outcome Score (KOOS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and Oxford knee Scores all improved significantly post-surgery ($P < 0.001$) but they reported 1 patient had progressed to develop lateral compartment OA of the knee at 28 months post UKR [18]. A recent systematic review by Volpin *et al* concluded that UKR and ACL reconstruction can be a valid treatment option for a selected cohort patients with knee instability and medial knee OA pain and our study using the fixed bearing Physica ZUK medial UKR confirms these findings [23].

The surgical decision whether to undertake a combined ACLR and UKR is important due to the technical challenges involved. This combined procedure is ideal for the young active patient with a prior traumatic ACL tear resulting in functional instability who later develops medial compartment knee OA as a consequence of the deterioration of the secondary restraints of tibial translation. Some health care providers worldwide ration knee replacement surgery on the basis of body mass index (BMI) however recent data in the United Kingdom has shown that obesity (BMI > 30) should not be considered a contraindication to medial UKR and that patients with high BMIs no difference in implant survival compared to patients with normal weights [24]. Data from the combined Swedish and Norwegian National Knee Ligament registrars have demonstrated that patients with BMI over 25 are at increased of graft failure after initial ACL surgery requiring a revision operation [25]. Currently, there is no published long term results on the survivorship of a combined ACL reconstruction and UKR in patients with a high BMI. In our current practice we do not ration the combined ACL reconstruction and medial UKR procedure based on BMI alone, however future long term studies may help identify whether a preoperative high BMI is an independent predictor for early failure after this operation.

In primary medial compartment OA with an intact ACL the antero-medial compartment is the area where there is most joint OA erosion [3]. These cases are ideal for a medial UKR if the patellofemoral and lateral compartments are well preserved. However as the knee OA progresses there may be attrition of their ACL due to aging process, resulting in more posterior tibial bone erosion, however these patients rarely report symptoms of knee instability due to the presence of an intact, stiff capsule. We report excellent clinical and functional results using the combined fixed bearing Physica ZUK medial UKA

and ACL reconstruction in patients with a mean follow up of 5.1 years. Implant survivorship is essential for any arthroplasty and the authors are encouraged by the recent publication by Gill *et al* who have reported the survivorship of the fixed bearing medial ZUK UKR to be 97.9% (95% CI 95.6–99.0%) at 12 years [20]. Future long term follow up studies of survivorship are required to assess the benefits of this combined approach, however our series has highlighted the significant improvement clinical and activity related outcomes in patients ACL deficiency and isolated medial compartment OA.

5. Conclusion

Combined single stage ACL reconstruction and fixed bearing medial UKR is an effective and valid surgical option for young, highly active patients with ACL deficiency and debilitating medial compartment OA pain with significant functional and clinical improvements seen after surgery.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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