ORIGINAL RESEARCH PAPER

Orthopaedics

CLINICAL AND FUNCTIONAL OUTCOME OF PROXIMAL FIBULAR OSTEOTOMY AND ARTHROSCOPIC DEBRIDEMENT FOR MEDIAL COMPARTMENT OSTEOARTHRITIS OF KNEE

KEY WORDS: Medial Compartment Osteoarthritis, Proximal Fibular Osteotomy, Ratio Of Knee Joint Space

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ABSTRACT

OBJECTIVE: To explore the effects of proximal fibular osteotomy and Arthroscopic debridement for pain relief and improvement of medial joint space and function in patients with knee osteoarthritis. **METHODS:** From January 2018 to December 2019, 22 patients who underwent proximal fibular osteotomy and arthroscopic debridement for medial compartment osteoarthritis were retrospectively followed up. To analyse the alignment of the lower extremity and ratio of the knee joint space (medial/lateral compartment preoperative and postoperative weight-bearing and whole lower extremity radiographs were obtained. Preoperatively and postoperatively at 6wks, 3 months, 6 months and 1 yr using a visual analogue scale,knee pain was assessed and knee ambulation activities were evaluated using the American Knee Society score **RESULTS:** Medial pain relief was observed in 20/22 patients after this procedure. Most patients exhibited improved walking postoperatively. An average increase in the postoperative medial knee joint space was seen in weight-bearing lower extremity radiographs. Additionally, obvious correction of alignment was observed in the whole lower extremity radiographs in 2 of 22 patients. But 25 % of patients had common peroneal nerve neuro-praxia which got improved over the period of average 6 months. **CONCLUSIONS** This study demonstrates that proximal fibular osteotomy and arthroscopic debridement in patients with medial compartment osteoarthritis effectively relieves pain and improves joint function at a mean of 15 months postoperative.

INTRODUCTION

Joint pain, dysfunction and joint deformity as the main clinical symptoms with joint structure degradation and cartilage destruction and hyperplasia are the pathological characteristics of Knee Osteoarthritis (KOA)

Arthroscopic debridement, High Tibial Osteotomy (HTO), proximal fibular osteotomy and unicompartment or artificial total knee arthroplasty are surgical methods for KOA. Arthroscopic knee surgery with is common for middle or older people with persistent knee pain.1 The knees of these patients often has "degenerative" lesions of cartilage, meniscus, suggestive of osteoarthritis. Population based studies using magnetic resonance imaging show that incidental findings of such lesions are also very common among those without plain radiographic signs of osteoarthritis and among people without knee symptoms, suggesting that the clinical significance of such findings is unclear. A single arthroscopic debridement can only alleviate symptoms of pain and is associated with high recurrence rates [2]; arthroplasty is mainly used in patientsaged over 60 years and could cause serious trauma [3];osteotomy can correct varus-valgus deformity, recover the normal alignment of the lower limbs, reduce the stress concentration on articular surfaces, effectively relieve pain,delay joint degeneration and prevent or delay joint replacement [4]. Satisfaction rate in HTO which includes valgus proximal tibial osteotomy and supracondylar femoral osteotomy,in a 10-year follow-up period can reach up to 60% [5,6]. Proximal fibular osteotomy indirectly initiates KOA and promotes its progression as it is based on the 'theory of differential settlement' [7]. Minimal trauma, few complications, definite effects and wide clinical applications are the characteristics of this treatment approach [8]. The available evidence on the benefits of proximal fibular osteotomy was analyxed by this study.

PATIENTS AND METHODS

From January 2018 to December 2019, 22 consecutive patients who underwent PFO with arthroscopic debridement at our hospital were followed retrospectively.Knee pain with difficulty walking due to medial compartment osteoarthritis or genu varus were the inclusion criteria . According to the American College of Rheumatology criteria the diagnosis of osteoarthritis was made by a clinician.7 The exclusion criteria were genu valgus, acute major trauma,inflammatory joint disease, malignant tumours, and abnormal renal or liver function. All patients were provided informed consent prior to implementation of the study procedures The patients were placed in the supine position after administration of anaesthesia. An approximately ---cm longitudinal incision was made over the lateral skin of the proximal fibula, and the fibula was exposed between the peroneus muscle and soleus muscle. By removing a 2- to 3-cm length of fibula at a site 6 to 10 cm from the caput fibulae PFO was performed Full weight bearing and free mobilization were allowed postoperatively as suited by the patient. Using a visual analogue scale knee pain was assessed. Knee ambulation activities were recorded using the knee and function subscores of the American Knee Society score preoperatively and at a mean of 6weeks,3 months,6 months and 1 year postoperatively. Preoperative and postoperative weightbearing and whole lower extremity radiographs were obtained in all patients to analyse the alignment of the lower extremity and the ratio of knee joint space (medial/ lateral compartment). Two horizontal lines (C and D) that were drawn from the lowest point of the medial condyle of the femur and medial plateau of the tibia, respectively had a vertical line (A) between them to determine , the medial joint space. The lateral joint space was decided by a vertical line (B) between two horizontal lines (E and F) that were drawn from the lowest point of the lateral condyle of the femur and tibia. Ratio of A/B determines the

ratio of the knee joint space (medial/lateral). The whole lower extremity radiograph helped to measure the hipknee- ankle .Line A was drawn from the centre of the femur to the centre of the knee, and line B was drawn from the centre of the knee to the centre of the ankle. The hip-knee-ankle angle was the intersection angle a between lines A and B

RESULTS

A total of 22 patients (22 knees) were included in this study out of which 11 knees were of males and 11 knees were of females.The age of the patients ranged from 40 to 68 years with the mean age being 52.5 years. 76.15 ± 11.575 and 82.78 +/- 10.639 points, 17.69 ± 15.359 points and 20.00 ± 12.247 points,was the average preoperative VAS score, KNS score in mild and modrate osteoarthritis respectively (Figure 3). There was a noticeable medial pain relief seen in all patients after PFO.Postoperatively,the mean visual analogue scale scores significantly decreased to 21.15 and 8.89 at 6 months. There was significant improvement in the average postoperative KNS scores in mild and moderate osteoarthritis which is 81.54 ± 17.723 points and 78.89 ± 22.608 points . There was also a significant improvement in the ratio of the knee joint space (medial/ lateral compartment)

DISCUSSION

Biomechanics of varus knee osteoarthritis

With increasing grade of OA of the knee, femoral neckshaft valgus angle decreases and lateral bowing of the femoral shaft increases, reducing the condylar shaft angle and shifting the mechanical axis medially, whereas on the tibial side, especially in the early stages of OA tibial plateau compression leads to a steepening of medial plateau more than bowing of tibia, [8].Progress of medial OA occurs more due to medial tibial compression rather than to bowing of the tibia [8]. The apparent density of trabeculae, trabecular architecture and the strength of the bone material are the determinants of compressive strength and stiffness of trabecular bone [9]. Perpendicular to the joint surface of the proximal tibia the primary trabeculae of the epiphysis are oriented [9].No difference in the medial and lateral tibial condyles according to the age-related changes and mechanical properties of subchondral trabecular bone [10]. However, trabecular bone has been resorbed at a faster rate in women than men thereby putting them at higher risk than men collapse of metaphyseal trabecular bone [11, 12]. In the proximal tibia, which is predominantly a cancellous bone, the trabeculae rather than the peripheral cortex share most of the load [9]. Hence, age-related trabecular resorption in the proximal tibia leads to the risk of collapse. This.Hvid does not affect tThe fibula, being a predominantly cortical bone[9] worked on the loading pattern and strength of the proximal tibia and found that loading and in the central and anterior sections of the medial tibial plateau, consequently the strength of bone is maximal whereas these occur posteriorly in the lateral tibial plateau. Medial side is found to take more load compared to the lateral side.Minimal change is there in the cortical thickness in the proximal fibula with age but the loss of strength is more significant in the proximal tibia [13]. Between 6.5 and 16% of the total load borne by the lower limb have been reported the loads transmitted by the fibula [14]. When the ankle joint was in full dorsiflexion and the subtalar joint was in full eversion maximum fibular loading occurs [14]. All the above studies indicate that loading through the fibula is relatively well preserved with age and the fibula contributes to supporting the lateral column of the proximal tibia.

Wear patterns in knee osteoarthritis

As PFO aims to reverse these changes therefore it is important to understand the normal wear patterns in OA of the knee. Wear is seen commonly in the anteromedial aspect of the medial compartment [15] and posterolateral part of the lateral compartment in osteoarthritic knees with normal alignment and an intact anterior cruciate ligament (ACL), [16]. The wear patterns correspond with the loading pattern of the proximal tibial articular surface described above by Hvid [9]. In osteoarthritic knees with deficient ACL, the worn area is wider on the medial compartment and involves the posterior aspect of the medial compartment

Origin of proximal fibular osteotomy

Yazdi et al. [17] in 2014 first reported an increase in the lateral compartmental and a decrease in the medial compartmental pressure and pressure after fibulectomy.Joint reaction forces across cadaveric knees was surveyed after fibulectomy for other reasons, e.g., fibular-cuff resection for non-union of the tibia, fibular tumor resection, fibula graft harvest, etc. The authors suggested that performing fibulectomy along with periarticular knee osteotomiescan have protective effect by reducing pressure over the knee joint. The following year, Yang et al. [18] published series of PFO surgeries performed since 1996 at the Third Hospital of Hebei Medical University, Hebei, China.

Rationale behind proximal fibular osteotomy

Many mechanisms appear to interplay after PFO. We discuss each of these below.

The concept of non-uniform settlement

From the field of architecture the word "settlement" has been borrowed where the phenomenon of gradual sinking after the construction of a structure is seen [20]. The bone density of the fibula was found to be higher than the medial tibial plateau. With osteoporosis, the support of the fibula by the lateral tibial plateau does not allow the lateral side to "settle" creating a varus deformity. This has been called non-uniform settlement [20]. There is side-slipping of the femoral condyle medially during walking and playing sports which aggravates the non-uniform settlement due to excessive loads on the medial side when the medial side "settles" down [18]. The rationale behind PFO is that when this support of the fibula is removed, the lateral side "settles" down, loading the proximal tibia evenly and corrects the deformity in a varus knee,relieves symptoms and reduces deformity. It was found in clinical studies of PFO that varus deformity improved following PFO [18, 19, 24].When the continuity of the fibula is interrupted, the loads borne by the lateral column of the proximal tibia increases resulting in "settling" on the lateral side [21, 24] (Fig. 1). Settlement value has been studied by Dong et al. [20] and found to be positively related to the KL grading of OA of the knee and negatively related to the hip-knee angle (HKA) and. Settlement value was defined as the distance from a perpendicular drawn through the highest point in the lateral tibial condyle to the lowest point of the medial condyle of the tibia in an anteroposterior view of the knee, [20] to the tibial mechanical axis. It has been found that varus alignment increases the progression of OA [25]. The greater the varus, the greater the chances of progression and hence reducing the varus by PFO decreases the progress of OA. The too-many-cortices theory Another theory is that the medial condyle is supported by one cortex whereas the lateral condyle is supported by two fibular cortices and one tibial cortex and when the medial side collapses in a varus-deformed knee with an intact fibula making itdifficult to balance loading

Slippage phenomenon

After the development of varus due to non-uniform settlement, the femur slides to the medial side as is evident in plain radiographs of patients with medialcompartmental OA. This phenomenon is called coronal tibio-femoral subluxation or the slippage phenomenon.

This phenomenon further tends to increase the high Knee Adduction Moment (KAM), thereby further enhancing the non-uniform settlement, leading to progression of varus deformity.

The concept of competition of muscles Huang et al. [26] proposed that between biceps femoris and peroneus after high-fibular osteotomy there was a competition of muscles. He found that muscle activity increased in the long head of biceps femoris and decreased in the peroneus longus on the side operated on immediately after high-fibular osteotomy.

This explained why immediately after high-fibular osteotomy there was immediate improvement in HKA angle from a more varus to a more neutral alignment. This finding is explains the immediate pain relief after

Dynamic fibular distalization theory

Qin et al. [27] in their prospective study of 67 PFOs found that significant clinical improvement after surgery was proportional to the amount of distalization of the fibula and the inclination angle of the proximal tibiofibular joint. The authors conceptualise that after PFO, the proximal fibula was no longer subject to compressive forces of weight transmission from the distal fibula. However, muscles attached to the proximal fibula, such as the soleus and peroneus longus, pulled the fibular head in the distal direction, and the tensile force was simultaneously transmitted to the lateral femoral condyle, This theory was supported by the finding that more significant the improvement in symptoms with the correction of the varus deformity was seen after greater the distal displacement of the fibular head, the better was the correction of the varus deformity. Ground reaction vector readjustment theory Xie et al. [28] in 2018, biomechanical changes in ground reaction vector (GRV) action mainly at the foot level caused immediate symptomatic relief after PFO. The authors proposed that after PFO, the lateral malleolus migrates proximally, pulling the calcaneus into further valgus through the calcaneofibular ligament. There was no proximal migration of the lateral malleolus. Ankle valgus improved after PFO and theu did not note any significant anatomical valgus alignment at the ankle postoperatively,.

Procedure

Various approacheshave been used to resect a segment of the fibula6–10 cm below the fibular head.Huang et al. [26] advocates removing a 1-cm segment offibula 7–8 cm from the head of the fibula by accessing itthrough the inter-muscular space between the extensor digitorum longus and peroneus longus/peroneus brevis,under local anesthesia. Others have used an approach betweenthe peroneus and the soleus and removed a 2-cmsegment 6–10 cm below the fibular head [20, 30].The surgical approach should primarily be influenced by course of the common peroneal nerve (CPN) and effortsto minimize damage to the nerve or its branches. Accordingly,the plane of dissection to approach the fibula andthe zone of fibula resected are of prime importance.It has been shown in studies of fibular osteotomies accompanyinghigh-tibial osteotomies that it is safe to excise the fibula from the lower half. This zone at the junction between the proximal two thirds and the distal third of the fibula had the least incidence of peroneal nerve When an osteotomy is needed in the proximal half, it should be performed to avoid the peroneal nerve and its branches which are in anterior to the coronal plane through an incision posterior [32].

It is not presently clear whether resecting the fibula from the distal half for patients over resecting the proximal fibula confers any benefits over undergoing isolated fibular osteotomy for medial OA of the knee.

After diagnostic arthroscopy the rough articular cartilage was shaved (chondroplasty was performed), joint was lavaged with 10 litres of fluid,,all torn or degenerated meniscal fragments were trimmed.No abrasion arthropalsty or microfracture was performed.Typically bone spurs were not removed,but any spurs from the tibial spine area that blocked full extension were shaved smooth Blaimont et al. found that the surgical effects of HTO are superior, but the excessively high osteotomy plane increases the risk of tibial plateau fracture and proximal necrosis [9].Hence, HTO is not recommended for patients with severe osteoporosis or for the elderly . Sprenger et al. [10] and Minzlaff et al. [11] observed satisfactory long-term effects of lateral tibial closing-wedge osteotomy on KOA patients with varus deformity. The main advantages of medial tibial opening wedge osteotomy over lateral closing osteotomy are that the proximal fibula osteotomy is avoided, lateral fibular head does not need to be exposed injuries of the peroneal nerve and lateral collateral ligament are reduced and the lateral soft tissue tension is retained. Koshino et al. [12] and Takeuchi et al. [13] confirmed that medial tibial opening-wedge osteotomy can obtain satisfactory mid- and long-term effects. Domical tibial osteotomy is used for children with lower limb valgus–varus deformities. However, this approach is less stable than wedge. In proximal fibula osteotomy, the fibular head is pulled to the distal end through the soleus muscle and peroneus longus to form a lever structure,. Hence, the load of the knee joint is transferred from the medial plateau to the lateral plateau, and the distal femoral mechanical axis is rearranged to relieve the lateral soft tissue tension of the knee joint and remove KOA symptoms [16]. Some studies also argued that this procedure is associated with low intra-osseous pressure and pain relief [17]. The key to fibular osteotomy is the accurate fibular osteotomy height and length and the peroneal nerve protection. Performing fibular osteotomy in an area 4-7 cm away from the fibular head lowers the risk of peroneal nerve injury and produces satisfactory curative effects after operation [18]. HTO is used to directly correct varus deformity of the knee joint, and its indirect correction capacity is stronger than that of fibular osteotomy; therefore, HTO is more appropriate for patients with serious varus deformity than fibular osteotomy [19]. The present study showed that proximal fibular osteotomy decreased the operation time, bleeding amount during operation and drainage volume after operation while shortened the full weight-bearing time; decreased the pain VAS and FTA and increased the JOA score of the knee joint; and decreased the incidence of complications. These results suggest that the short-term and long-term surgical effects of proximal fibular osteotomy on varus KOA are superior to those of HTO, which has certain clinical promotion value. The long-term therapeutic effect of fibular osteotomy needs further follow-up observation.

Conclusion

The present study demonstrates that proximal fibular osteotomy and arthroscopic debridement effectively relieves pain and improves joint function in patients with medial compartment osteoarthritis at a mean of 15 months postoperative.

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