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Review

## Distraction to treat knee osteoarthritis

Charles-Henri Flouzat-Lachaniette\*, François Roubineau, Clémence Heyberger, Charlie Bouthors

Service de chirurgie orthopédique et traumatologique, hôpital Henri-Mondor, AP-HP-UPEC, 51, avenue du Maréchal-de-Lattre-de-Tassigny, 94010 Créteil cedex, France

### ARTICLE INFO

*Article history:*

Accepted 21 March 2016  
Available online xxx

*Keywords:*

Osteoarthritis  
Knee  
Joint distraction  
Cartilage  
Magnetic resonance imaging  
Complications.

### ABSTRACT

The objective of this article is to review data on joint distraction used to treat knee osteoarthritis. Joint distraction is a surgical procedure in which the two bony ends of the joint are gradually pulled apart then kept separated for 2 months in an external fixation frame. Weight bearing is continued to ensure variations in hydrostatic pressure within the joint. In published studies, joint distraction provided substantial clinical and structural improvements in patients with knee osteoarthritis, delaying joint replacement surgery for at least 2 years. Animal studies showed that joint distraction was associated with decrease in the secondary inflammatory response, cartilage breakdown, and subchondral bone remodeling. In vitro, the intermittent application of hydrostatic pressure stimulated the production of extracellular matrix, particularly in joints with osteoarthritis. Nevertheless, several considerations invite caution when considering the more widespread use of joint distraction. Published studies have short follow-ups and small sample sizes. In addition, the high frequency of pin tract infection is of concern, since most patients eventually require knee replacement surgery. These two considerations indicate a need for longer-term prospective studies of patient cohorts.

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### 1. Introduction

Osteoarthritis is a progressive joint disease characterized by cartilage degeneration, subchondral bone remodeling, and secondary inflammation of the synovial membrane. It is the most prevalent chronic joint disease, with about 10% of individuals older than 60 years being affected worldwide [1,2]. The clinical presentation combines pain and joint stiffness responsible for functional impairment [1,3]. The incidence of osteoarthritis is rising due to the aging of the population and increasing prevalence of obesity [1]. Knee osteoarthritis has an age- and sex-standardized incidence rate of 240/100,000 person-years [4].

In patients with early knee osteoarthritis, the treatment aims to alleviate the pain and stiffness and to maintain function. Three main treatment modalities are used alone or in combination: non-pharmacological interventions (e.g., physical therapy and orthotic devices), medications (e.g., analgesics and nonsteroidal antiinflammatory drugs), and surgery [1]. However, no treatment has been proven capable of halting or reversing the degenerative process [5]. Among surgical treatments for knee osteoarthritis, arthroscopic

lavage combined with debridement provided no short- or long-term benefits compared to a placebo [6]. Other surgical methods include osteotomy, arthroplasty, arthrodesis (which is very rarely used), and distraction (the focus of this review) [1]. Knee arthroplasty is highly effective in patients with severe symptoms that impair quality of life despite optimal conservative therapy [7]. This effectiveness has translated into a burgeoning number of arthroplasty procedures in industrialized countries, with the attendant heavy burden on healthcare resources [8]. Importantly, over 40% of all knee arthroplasty procedures are performed in individuals younger than 65 years [9]. Younger patients with higher functional demands are at increased risk for failure of knee arthroplasty [10]. Efforts have therefore been made to develop alternative treatment strategies for knee osteoarthritis that may delay the need for arthroplasty [11].

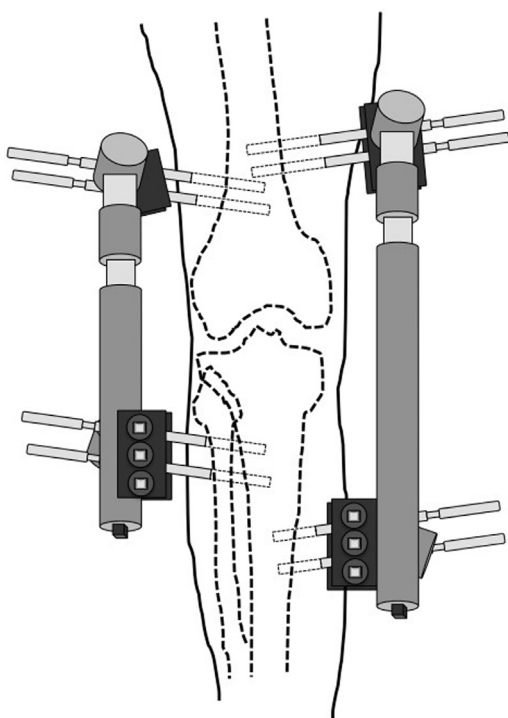
Joint distraction is a surgical procedure in which the two bony ends of a joint are gradually pulled apart, over a variable distance and for a variable period. The distraction is generally maintained by an external fixation frame (Fig. 1). The goal is to temporarily unload the joint cartilage by eliminating contact between the joint surfaces [12]. It should be noted that this technique unloads the cartilage temporarily, whereas unloading is permanent when tibial or femoral osteotomy is performed or a distracting device is implanted [13,14]. Joint distraction was initially used to treat joint malalignment or stiffness: the distraction served to protect the cartilage

\* Corresponding author.

E-mail address: [charles-henri.flouzat-lachaniette@aphp.fr](mailto:charles-henri.flouzat-lachaniette@aphp.fr) (C.-H. Flouzat-Lachaniette).

<http://dx.doi.org/10.1016/j.jbspin.2016.03.004>

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**Fig. 1.** Diagram of the external fixator consisting of two monotubes positioned laterally and medially to bridge the knee. The tubes are lengthened (by about 5 mm) to induce joint distraction. The coil springs within the monotubes act as shock absorbers and allow limited axial motion (3 mm) without contact between the joint surfaces.

from damage induced by repositioning the joint or manipulating it to increase range of motion [11]. The first reports that distraction was associated with improvements in the clinical manifestations of osteoarthritis were published in the 1990s [15–18]. Then, contrary to the usual research strategy, preclinical studies were performed based on these preliminary clinical observations, in an attempt to determine how distraction might be beneficial.

## 2. Early data about effects of distraction on the joint cartilage

Most of the early published studies focused on patients with ankle osteoarthritis or hip conditions [15–18]. Hip distraction was assessed in 80 patients with various hip diseases treated between 1979 and 1982 [18]. A 5-mm space was created using a single-axis articulated external fixator that allowed flexion and extension. After 5 to 8 years, results were good in those patients younger than 45 years with osteoarthritis, hip dysplasia, or avascular necrosis of the femoral head. Patients with inflammatory hip disease, in contrast, had no benefits. Distraction applied via an Ilizarov external ring fixator for 3 months was evaluated in 17 patients with post-traumatic osteoarthritis of the ankle [16,17]. With this technique, ankle fusion was postponed by at least 2 years, and over two-thirds of patients reported clinical improvements. More surprisingly, there was a lasting increase in joint space width, consistent with cartilage repair as the reason for the good medium-term clinical outcomes. Similar effects were reported in 3 patients with stiffness of the interphalangeal joint of the thumb, patellofemoral joint, and tibiotalar joint, respectively [15].

Unloading the joint cartilage can reverse the structural damage due to osteoarthritis [19]. To induce this effect, an implant that distracts the medial tibiofemoral compartment of the knee has been developed [20].

## 3. Joint distraction to treat knee osteoarthritis

### 3.1. Principles of distraction treatment for knee osteoarthritis

Intema et al. were the first to describe a joint distraction technique for treating knee osteoarthritis [11]. Under general anesthesia, two monotube external fixators (Monotube Triax, Stryker, Kalamazoo, MI, USA) were placed parallel to each other, on the medial and lateral side, respectively, to bridge the knee joint (Fig. 1). Each end of each monotube was fixed to the bone by a 6-mm self-drilling pin. The joint was then distracted by 2 mm. The pins were placed far from the joint line to avoid compromising the area needed for possible knee arthroplasty at a later date. Over the next 3 days, the amount of distraction was increased to 5 mm. Full weight bearing on the operated joint was allowed. The patients were seen every 2 weeks, for temporary removal of the monotubes and placement of the knee in a continuous passive motion device for 3–4 hours; in most cases, full extension was achieved, whereas flexion, determined by the degree of pin-site pain, was 25° on average. The monotubes were repositioned and a radiograph obtained to check that distraction was sufficient. After 2 months, the tubes and pins were removed on a day-hospital basis. The patients continued their rehabilitation program at home to regain normal range of motion.

### 3.2. Results of distraction in knee osteoarthritis

Two studies report the outcomes of distraction therapy in 20 patients who had advanced tibiofemoral osteoarthritis indicating arthroplasty and who were evaluated clinically and radiologically after 1 and 2 years [11,21]. The radiographic findings 1 year after distraction therapy included a significant increase in joint space width, from 2.7 to 3.6 mm ( $P < 0.05$ ) [11]. Concomitantly, magnetic resonance imaging (MRI) showed a significant increase in cartilage thickness, from 2.4 to 3.0 mm ( $P < 0.001$ ) and a significant decrease in denuded bone areas from 22 to 5% ( $P < 0.001$ ). Biomarker levels in serum and urine were not significantly changed. The WOMAC index increased from 45 to 77 points ( $P < 0.001$ ) and the pain score on a visual analog scale (VAS) decreased from 73 to 31 mm ( $P < 0.001$ ). After 2 years, the clinical, radiographic, and MRI improvements persisted, and the VAS pain score decrease was 61% (vs. 58% after 1 year) [21]. Of the 20 patients, 15 (75%) were good responders as defined by the OMERACT-OARSI [22]: either a 50% or greater improvement in the pain OR function WOMAC subscore with a 20-point or greater improvement in one of the categories; or an at least 20% improvement in the WOMAC pain AND function subscores with a greater than 10-point increase in both. The increase in joint space width was 59% after 2 years (vs. 51% after 1 year). No correlation was found between the clinical and MRI outcomes. However, in knee osteoarthritis the clinical manifestations show little relationship with the structural joint changes [23,24].

This distraction technique has been compared to the standard surgical techniques used to treat knee osteoarthritis, namely, high tibial open-wedge osteotomy (OWO) [25] and total knee arthroplasty (TKA) [26]. In a randomized controlled trial, 45 patients were allocated to OWO and 22 to joint distraction [25]. Both methods provided significant clinical improvements, but these were more marked with OWO. After 1 year, mean joint space width was significantly increased after distraction (0.77 mm) or OWO (0.48 mm). In an ongoing randomized controlled trial, 40 patients allocated to TKA will be compared to 20 patients allocated to joint distraction. The preliminary 1-year findings in 26 TKA patients and 16 distraction patients have been reported [26]. Both treatments provided significant clinical improvements, which were of similar magnitude in the two groups. Cartilage thickness data have not been reported.

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