Letter to the Editor

Ground reaction vector re-adjustment—the secret of success in treatment of medial compartment knee osteoarthritis by novel high fibular osteotomy

ARTICLE INFO

Keywords:

Ground reaction vector
Medial compartment knee osteoarthritis
Non-uniform settlement

ABSTRACT

High fibular osteotomy has been preliminarily proved to be an effective treatment of knee osteoarthritis by excising a segment of bone at the proximal part of fibula. This imaginative procedure is clinical validated by its instant and explicit knee pain resorption and eventually deformity correction. The rationale of this treatment is named non-uniform settlement of the tibial plateau and used to elucidate the cause of knee joint degeneration, but cannot illuminate the reason of prompt postoperative pain resorption faithfully. To assist in better understanding of this therapeutic method and raising alert to possible unexpected complications, we proposed a new theory to elucidate the pain relief mechanism.

Knee osteoarthritis (OA) is a chronic, progressive degenerative disease characterized by pain relating disability¹. Due to ageing population, the need of Total Knee Arthroplasty (TKA) as a common elective procedure is continually rising, and the major aim is to alleviate pain and improve physical activity². It is widely accepted that pain relief is the most important factor concerning prognosis, but immediately postoperative pain elimination during imperative and arduous rehabilitation training process seems to be impossible. Mid-term follow-up had shown up to 20% of TKA patients remain dissatisfied and require post-surgical supplementary medical treatment of pain, producing an additional burden for the national healthcare system³. Biomechanical analysis has shown that in single-leg stance the ground reaction vector (GRV) is positioned medial to the knee joint center and results in 62%–79% of the load passes through the medial compartment of the knee and 21%–38% through the lateral compartment⁴, which is suggested as a predisposing factor for osteoarthritis⁵ (Fig. 1.) According to this theory, high tibial osteotomy is designed to realign lower limb mechanical axis. But this surgery is technique demanding and frequently associated with patellofemoral disturbance, delay union and hardware failure. So the therapeutic outcomes of surgical treatments to knee OA are not always optimal, they are associated with relatively high complication rate and high economic burden.

Recently, Zhang et al. reported their preliminary results of a novel procedure in treating medial compartment knee osteoarthritis⁶. This innovative surgery applied a simple proximal fibular osteotomy, after surgery the knee joint pain was alleviated almost immediately and maintained for long term. Technically, this procedure was straight-forward and low-cost. The follow-up (a mean of 12.4 months, range from 7 to 17 months) showed significant improvement of visual analog scale (from 7.0 preoperative to 2.0 postoperative), on radiograph the lower limb mechanical axis and knee joint malorientation were both corrected finally (mean FTA from $182.7^\circ \pm 2.0^\circ$ to $179.4^\circ \pm 1.8^\circ$). The main complication was paralysis of common fibular nerve which often resolved spontaneously⁷.

The rationale of this procedure is that the lateral support provided to the osteoporotic tibia by the fibula-soft tissue complex may lead to the non-uniform settlement and degeneration of the tibial plateau bilaterally^{8,9}, so this procedure designed to eliminate this inessential supporter. Although the rationale of this procedure seems relatively intuitive and needs more study, the mechanism which causes quick and impressive symptom resorption is more obscure when considering there are substantial amount of the patients got impressively prompt pain mitigation soon after surgery^{8,9}. Zhang and his colleagues also stated that at the end of the follow-up the mechanical axis of the affected limb was improved and the knee joint pain relief could be attributed to it. Because the process of natural settlement of knee joint is obviously time consuming, it is unlikely to expect the restore of established unbalance settlement, reposition of the GRV and correction of knee joint malorientation were caused by instant postoperative lateral plateau settlement from sole high fibular osteotomy. In other words, the removal of lateral support effect of fibular-soft tissue is insufficient to rebalance lateral and medial tibial plateau settlement and relieve the over-load of the medial tibial compartment immediately after the surgery. Furthermore, the operation left knee joint structure intact and no attempted to elevate the medial plateau, there should be some unrecognized mechanism leading to lower limb realignment and prompt pain alleviation. To the best of our knowledge, there is no reasonable and wide accepted explanations have been proposed.

Based on our experience of foot and ankle deformity correction, we hypothesize that the realignment of affected limb and knee pain resorption originate from re-adjustment of GRV line at the distal point other than direct correction at the knee joint level. On coronary plane, the trapezoid talus is stabilized by the fork shaped mortise and with minimal movement. When a segment of bone is excised from the proximal part of fibula, the interosseous membrane and surrounding soft tissue are not stiff enough to prevent proximal migration of the distal part of fibula during stance phase, which results in a functional shortening of the later malleolus. When the lateral bony buttress of the mortise is disrupted, combined with the normal lateralized location of GRV at the ankle joint level and lateral offset of calcaneal mechanical axis referring to the tibia's, the talus will inevitably

Fig. 1. Demonstration of the location of ground reaction vector (GRV) at T10, knee and ankle joint level. At knee, the GRV is medial deviated compared to the lower limb mechanical axis. At ankle, GRV approximately locates at the lateral wall of calcaneus.

valgus especially in single-leg stance when the valgus vector at ankle peaks (Fig. 2). In the chronic scenario, with gradual ligament stretch the valgus deformity of talus can be well compensated by subtalar varus, but after high fibular osteotomy surgery the intact surrounding ligaments limit subtalar joint movement. Fibulocalcaneal ligament may play a major role in this process because of its attachment on the lateral wall of calcaneus and fibular tip which migrates proximally, ultimately applies a strong valgus vector on ankle and subtalar joints. The net effect of calcaneus valgus is to move the point of contact between foot and ground more laterally (Fig. 3), which leads to GVR move towards the lateral plateau at the knee joint. The similar compensation mechanism can be explored in the patients with varus knees, who would pronate foot which contains element of hindfoot valgus to move the origin of the GRV laterally and therefore closer to the center of the knee, reducing the adductor momentum at the knee and alleviate medial plateau loading¹⁰.

This proposed mechanism originates from our prior knowledge, and should be validated by in vivo test, such as comparing the change of calcaneal mechanical axis and GVR before and after fibular osteotomy in the knee OA patients. As an optimal therapeutic method, it is not only essential to yield sound treatment results, a fully comprehension of relating side-effect and complication is also extremely vital. With the segmental removal of fibular, the negative effect on ankle is a logical and possible outcome. So the purpose of this paper is not only to further our understanding of this original knee joint OA treatment, we also believe that where this surgery could alter joint orientation of ankle and subtalar joint, there is place to warn the surgeon and patient the possible of its detrimental effect on those joints.

Fig. 2. With the disruption of buttress effect of the lateral malleolus, there would be a tendency of valgus at subtalar articulation, especially during the stance phase.

Fig. 3. With right foot's hindfoot valgus which is caused by functional shortening of lateral malleolus, the GRV' is significantly lateralized compared to the GRV of neutrally aligned foot.

References

1. Focht BC. Move to improve: how knee osteoarthritis patients can use exercise to enhance quality of life. *ACSMs Health Fit J.* 2012;16(September (5)):24–28.
2. Hootman JM, Helmick CG. Projections of US prevalence of arthritis and associated activity limitations. *Arthritis Rheum.* 2006;54(1):226–229.
3. Bourne RB, Chatsworth BM, Davis AM, et al. Patient satisfaction after total knee arthroplasty: who is satisfied and who is not? *Clin Orthop Relat Res.* 2010;468(1):57–63.
4. Hsu RW, Himeno S, Coventry MB, et al. Normal axial alignment of the lower extremity and load-bearing distribution at the knee. *Clin Orthop Relat Res.* 1990;255:215–227.
5. Van der Schoot DK, Den Outer AJ, Bode PJ, et al. Degenerative changes at the knee and ankle related to malunion of tibial fractures. 15-year follow-up of 88 patients. *J Bone Joint Surg Br.* 1996;78(5):722–725.
6. Yang ZY, Chen W, Li CX, et al. Medial compartment decompression by fibular osteotomy to treat medial compartment knee osteoarthritis: a pilot study. *Orthopedics.* 2015;38(December (12)):1110–1114.
7. Wu LD, Hahne HJ, Hassenpflug T. A long term follow-up study of high tibial osteotomy for medial compartment osteoarthritis. *Chin J Traumatol.* 2004;7 348–343.
8. Zhang Y, Li C, Li J, et al. The pathogenesis research of non-uniform settlement of the tibial plateau in knee degeneration and varus. *J Hebei Med Univ.* 2014;35(2):218–219.
9. Zheng Z, Sun Y, Zhang X, et al. The pathogenesis and clinical imageology research of the knee osteoarthritis. *J Hebei Med Univ.* 2014;35(5):599–600.
10. Paley D. Ankle and foot considerations. In: Paley D, ed. *Principles of Deformity Correction*. revised ed. Berlin: Springer; 2005:730 [1st edn Corr. 3rd printing].

Wenjun Xie, Yu Zhang*, Xiaodong Qin, Lijun Song, Qun Chen
Jiangsu Province Hospital, Guangzhou Road 300, Jiang Su, China
E-mail address: 1921700122@qq.com

* Corresponding author.