

Critical Analysis of Biomechanical and Biological basis of Management of the Varus Knee

Karan Alva¹, Varun Gupta^{2*} and Prabhjot Gupta³

¹Department of Orthopaedics and Regenerative Medicine, Canterbury Christ Church University, Chatham Maritime, Kent, United Kingdom

²Senior Orthopaedic surgeon, Sehgal Neo Hospital, New Delhi, India

³Prakash Multispecialty Hospital, Khandwa, Madhya Pradesh, India

*Corresponding author: Varun Gupta, Senior Orthopaedic surgeon, Sehgal neo hospital, 110039, New Delhi, India, Tel: 9654450789; E-mail: Drvarun1234@gmail.com

Received date: February 26, 2018; Accepted date: July 13, 2018; Published date: July 18, 2018

Copyright: © 2018 Alva K, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Abstract

Stability of the knee depends on the alignment of the long bones, the structure of the articular cartilage or the soft tissue structures surrounding the knee mainly the ligaments and the capsule. Varus deformity of the knee increases the load on the medial compartment causing progressive degenerative changes leading to medial compartmental osteoarthritis. Julius Wolff in the early 19th century defined Wolff's Law which states that bone in a healthy organism will adapt to the loads under which it is placed. This means that biological responses can be mathematically determined in relation to mechanical forces in remodelling.

Keywords: Varus knee; Medial compartment; Osteoarthritis; High tibial osteotomy

Introduction

Stability of the knee depends on the alignment of the long bones, the structure of the articular cartilage or the soft tissue structures surrounding the knee mainly the ligaments and the capsule. Varus deformity of the knee increases the load on the medial compartment causing progressive degenerative changes leading to medial compartmental osteoarthritis. Julius Wolff in the early 19th century defined Wolff's Law which states that bone in a healthy organism will adapt to the loads under which it is placed. Hence, mechanical forces acting on the knee joint are directly related to the biological responses with regards to remodelling. This summary is aimed to critically evaluate the role of combining biological management along with biomechanical management in medial compartment lesions of the knee. The primary goal of performing this procedure is to defer the need for arthroplasty as the longevity of the implant is finite. This procedure adds to the health economic burden of revision surgeries with an ever-increasing ageing population. The increased demands of an athletic young population also manifest a need to explore regenerative methods rather than an arthroplasty.

Factors Involved in Varus Knee

In a varus knee, there is a failure of the biological component, i.e. the cartilage or the biomechanical component which is the mechanical axis of the lower limb. Change in either of the two components predisposes the other and leads to the progression of the pathology.

Biological Failure

Articular Cartilage is an aggressively specialised connective tissue without any blood supply, lymphatics or nerves with limited healing potential. Since it is viscoelastic, when there is constant compressive

stress, its deformation increases which is progressive until a plateau is attained [1]. These forces if progressive over extended periods of time finally give way breaking the collagen fibrils and the matrix causing cartilage degradation.

Cartilage oligomeric matrix protein (COMP) which is extracellular matrix glycoprotein, is released into the joint which further stimulates the release of pro-inflammatory cytokines like interleukin's, transforming growth factor α (TNF- α) which leads to further progression of the disease process [2].

Managing Biological Failure with Cartilage Regeneration

This can be attempted by any of the procedures either by using autologous chondrocyte implantation (ACI), micro-scaffold induced chondrogenesis (MSIC) among others. ACI is a two-staged procedure where chondrocytes harvested during the first procedure are cultivated in-vitro to be implanted as a second procedure after 4-6 weeks; whereas MCIC is a single stage arthroscopic procedure where mesenchymal cells harvested from the patient's iliac crest and implanted at the defect site using a scaffold. Smaller the size and localised the lesion better is the outcome of surgery. ACI is still considered to be the gold standard in the treatment of cartilage regeneration.

Biomechanical Failure

Because of the increased wear on the medial compartment of the knee, there is a shift in the mechanical axis of the lower limb. In the varus knee, the axis shifts medially increasing the lever arm. The body tries to compensate this by increasing adduction of the femur and external rotation of the foot with further contributes to the associated pain and deformity.

Managing Biomechanical Failure with High Tibial Osteotomy (HTO)

Popularised in 1965, HTO was introduced in 1961 to address this issue by realigning the mechanical axis and transfer the weight to the unaffected lateral compartment and reduce the strain and stop the degeneration in the medial compartment. It can be attained either with a medial opening wedge or a lateral closing wedge osteotomy both with its merits and demerits [3,4].

The most common method of determining the angle of correction required used the one described by Dugdale et al. according to whom the weight-bearing line which connects the center of the femoral head and the center of the tibiotalar joint is located at 62.5% between the medial and lateral compartment of the proximal tibia, slightly lateral to the lateral tibial spine [5]. Another popular method was described by Fujisawa et al. is to align the mechanical axis to pass through a point 30 to 40% lateral to the midpoint [6].

Managing Biomechanical Failure with Computer-Assisted-Navigated HTO

Traditional intra-operative measurement technique showed frequently intra-observer variations. Also, there was a significant amount of rotational mal-alignment which was not addressed. Keeping in mind these problems of HTO, computer-assisted navigated HTO seemed to gain preference in a few centers with encouraging early results. Lorio et al. [7] in 2011 published a randomised control trial of patients undergoing conventional or computer-assisted HTO who were followed up for an average period of 39 months. This showed significant difference favouring computer-assisted HTO with a higher amount of reproducibility both in the mechanical axis and tibial slope compared to pre-operative assessment.

Combining Biological and Biomechanical Processes

Since there is involvement of both the biological and biomechanical components, it seems logical to address both these components to achieve sustained benefit. A literature search was performed by using keywords 'high tibial osteotomy', 'cartilage regeneration', 'cartilage repair', 'varus knee'. A total of 90 articles were found which after evaluation by Shield's technique (SQ3R technique) were critically analysed.

HTO with Cartilage Regeneration

Feruzzi et al. [8] published a retrospective study of patients who underwent cartilage repair Procedures associated with HTO who were followed up for 11 years.8 Data from 138 patients were taken who were operated for varus deformity with medial compartment OA from 1999 in 2002. They found satisfactory results in both the groups at 11-year follow-up with n statistically significant evidence of the superiority of the addition of ACI to isolated HTO. A total of 56 patients who matched the criteria were included in the study. This can however not rule out possible deliberate exclusion since it is a retrospective study. No mention regarding an ethical committee, clearance is mentioned throughout the study. There is neither mention of the number of operating surgeons involved in the study. The patients were evaluated post-operatively only based on the Hospital for Special Surgery (HSS) knee assessment instrument and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) Rating score and X-rays. No repeat MRI or arthroscopy was done in any patient to evaluate the

status of cartilage growth. There were 6 cases which failed in the course of the follow-up and were converted to arthroplasty, the cause and the timing of revision not Explained. The strengths of the study were the strong emphasis on the inclusion criteria like including only patients with medial compartment OA and age less than 60 years. MRI was taken in all the operative cases pre-operatively to evaluate the cartilage status. ACI was performed arthroscopically in all the 18 cases.

A study was reported by Franceschi et al. [9] in 2008 of 8 patients who were evaluated for a period of 28 months after simultaneous ACI and HTO for chondral defects in varus knee. Their patients showed improvement post-operatively compared to similar studies. However, the study was conducted from January 2002 to February 2003 and published after five years.

The sample size of 8 was quite small with no associated control group to draw credible conclusion from the study. The angle of osteotomy to be done was considered to a center the point at 50% of the tibia which was not consistent with most other publications with HTO who considered the Dugdale method or the Fugisawa method. The strengths were all patients were treated with a medial opening wedge and the ACI was done arthroscopically.

Patients were evaluated for more than 2 years (25-31 months) with no known complications or revisions. MRI was done postoperatively at 5 weeks, the reason for which an early MRI or the results were not explained. However though interesting a paper, the credibility of the results should be analysed carefully considering all these limitations.

A systematic review was published in 2012 by Harris et al. which survival and clinical outcome of HTO with cartilage regeneration techniques. A total of 69 studies were included in this. The study which was selected between 1998 and 2012. They found that the survival of HTO combined with cartilage repair was significantly higher with only HTO or HTO in combination with the meniscal transplant. Majority of the cases (almost 75%) were of low level of evidence i.e. level III or IV. There was no mention regarding conflicts of interest in almost half of the cases making it difficult to exclude case selection bias in the study [10]. The different studies had adopted different methods of HTO, either a closing wedge or opening wedge making it difficult to compare the studies. The cartilage regeneration treatment varied from ACI, OATS, osteochondral allograft and other marrow-stimulation techniques. The methods of patient selection in the studies were quite arbitrary and most of the patients in the HTO only group had a mean age of 60 years whereas in the HTO with cartilage group were younger and more active giving rise to a suspicion of clinical bias and treatment offered based on the patient's clinical activity and age.

A non-randomized clinical trial done in year 2013, by Bode et al. showed outcomes of OWHTO (medial open wedge high tibial osteotomy) and ACI in 43 patients (mean age 39.14 years) and revealed a higher graft survival rate of 89.5% in the combined treatment group based on MRI findings and the need for revision surgery (compared to 58.3% in the ACI alone group) [11].

Results

The benefits of combining cartilage regeneration with HTO seem to have a slight benefit over Only HTO with better short-term survival. Long-term survival of both the treatment options is comparable at 10 years with similar survival rates. No publications have been found which study the outcome of cartilage regeneration techniques with high tibial osteotomy using navigation techniques which highlights the

need for more clinical information to draw definitive conclusions. Navigated surgery is also a niche surgery performed in few centers. It also adds to the cost of combination treatment making the procedure very expensive.

Conclusion

The spectrum of medial compartment lesions is quite broad and is difficult to group patients into a category. The ideal way to proceed with such situations is to optimize treatment with patient specific target therapy. There is no concrete high level evidence available regarding asurgical procedure which outweighs another. It is likely that a combination of the procedures is a logical management option and there is a need for more evidence. Cartilage regeneration with computer assisted HTO seems to be an ideal option, but there are no studies available to evaluate the outcome. The cost economics of this might need to be considered as navigation adds a significant cost to the procedure. There is a need for future research and high level evidence to shed light and evaluate its benefits on a long-term outcome.

References

1. Sophia Fox AJ, Bedi A, Rodeo SA (2009) The basic science of articular cartilage: structure, composition, and function. *Sports health* 1: 461-468.
2. Goldring MB (2000) Osteoarthritis and cartilage: the role of cytokines. *Curr Rheumatol Rep* 6: 459-465.
3. Coventry MB (1965) Osteotomy of the Upper Portion of the Tibia for Degenerative Arthritis of the Knee. A Preliminary Report. *J Bone Joint Surg Am* 47: 984-990.
4. Frost HM (2004) A 2003 update of bone physiology and Wolff's Law for clinicians. *Angle Orthod* 74: 3-15.
5. Dugdale TW, Noyes FR, Styer D (1992) Preoperative planning for high tibial osteotomy. The effect of lateral tibiofemoral separation and tibiofemoral length. *Clin Orthop Relat Res* 274: 248-264.
6. Fujisawa Y, Masuhara K, Shiomi S (1979) The effect of high tibial osteotomy on osteoarthritis of the knee. An arthroscopic study of 54 knee joints. *Orthop Clin North Am* 10: 585-608.
7. Lorio R, Pagnottelli M, Vadalà A, Giannetti S, Di Sette P, et al. (2013) Open-wedge high tibial osteotomy: comparison between manual and computer-assisted techniques. *Knee Surg Sports Traumatol Arthrosc* 21: 113-119.
8. Ferruzzi A, Buda R, Cavallo M, Timoncini A, Natali S, et al. (2014) Cartilage repair procedures associated with high tibial osteotomy in varus knees: clinical results at 11 years follow-up. *Knee* 21: 445-450.
9. Franceschi F, Longo UG, Ruzzini L, Marinozzi A, Maffulli N, et al. (2008) Simultaneous arthroscopic implantation of autologous chondrocytes and high tibial osteotomy for tibial chondral defects in the varus knee. *Knee* 15: 309-313.
10. Harris JD, McNeilan R, Siston RA, Flanigan DC (2013) Survival and clinical outcome of isolated high tibial osteotomy and combined biological knee reconstruction. *Knee* 20: 154-161.
11. Bode G, Schmal H, Pestka JM, Ogon P, Südkamp NP, et al. (2013) A non-randomized controlled clinical trial on autologous chondrocyte implantation (ACI) in cartilage defects of the medial femoral condyle with or without high tibial osteotomy in patients with varus deformity of less than 5°. *Arch Orthop Trauma Surg* 133: 43-49.