Overview of recent clinical studies on osteotomy

R.P. Jakob
Switzerland
«When someone asks me about why their patient "failed" the cartilage procedure they did, I always ask about alignment and the response is usually silence.»

William Bugbee
This topic is scarcely treated in literature of the past 10 years. It is a fact that during the early years of modern cartilage repair since the foundation of the ICRS (1997) osteotomy to correct misaligned knees in association with cartilage repair was kept on low flame.
This is reflected that in papers dealing with the subject, axial alignment of the patients was not usually measured, nor reported nor asked for by reviewers.
“Normal” and “tolerable” was, which was roughly 3-5° +/- off the normality. It could not been imagined enough that correction of overload alone could contribute to a positive result of a given cartilage repair or otherwise if left uncorrected could be responsible for a failure.
On the other side, among the proponents of “comprehensive” knee surgeon’s, osteotomy was the first gesture to use, even in slight deformity, when going about to indicate treatment of a given cartilage lesion.
Personally, for us cartilage repair was always handled comparable to a gesture like “osteotomy plus”.
What can we find in literature to guide us in this discussion?
The only broad study which tried to keep the entities apart and summing up metanalysis-like, is the systematic review.
The authors look at 69 studies, including 4557 patients and concomitant procedures with 7 yrs. follow up, mean subject age 53 yrs.
Survival of isolated HTO alone was
92% at 5
85% at 10
77% at 15
72% at 20 yrs.
of follow up.
HTO combined with articular cartilage surgery, had at 5 yrs. of follow up significantly greater survival (97,7%) than either isolated HTO (92%) or HTO with MAT (Meniscus Allograft Transplantation) (91%).
• However, at all other time points with or without combined articular cartilage surgery and/or MAT, there was no significant survival difference between the two techniques.

• Despite several statistically significant findings within this review, it must be emphasized that the clinical difference is small.
• The authors state that there are various limitations of such a study including sources of selection bias with heterogeneity in patients compared in this review:

• patients undergoing isolated HTO for medial arthrosis were older and likely less active, while patients undergoing combined biological knee reconstruction procedures were younger, more active, and likely to remain/desire to remain more active.
Conclusion 1: Despite significantly improved outcomes and low rates of complications and failures, combined “biological knee reconstruction” surgery is associated with a high rate of re-operation.
Conclusion 2: Isolated HTO, HTO with articular cartilage surgery and HTO with MAT all significantly improved subjective and objective clinical outcome scores.
There remains one unexpressed and unaddressed question:
Are the 6% improvement of the results at 5 yrs. worth the effort and money?
Feruzi et al compare retrospectively cartilage repair procedures (ACI or MFX) in 56 patients associated with high tibial osteotomy in varus knees with 11 year’s follow-up.
The hypothesis was that a cartilage repair procedure may add some benefit to isolated axial correction.
20 patients were treated by HTO,
18 by HTO+ACI and
18 by HTO+MFX.
• All patients underwent clinical assessment following HSS and WOMAC rating scores and a radiographic study was performed preoperatively and at follow-up.

• At final follow-up, improvements in clinical and radiographical results were obtained in all patients.
• HTO and HTO+ACI series showed significantly higher scores compared to the HTO+MFX series.
• They concluded that at more than 11 years of follow-up, isolated HTO and HTO+ACI treatments showed satisfactory results similar to those reported in the literature with no evidence of superiority of the addition of ACI to isolated HTO.
Conclusion 1, HTO plus MFX did less good than HTO alone or HTO plus ACI
Conclusion 2, ACI did not add to the good results of OT alone
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°

Gerrit Bode · Hagen Schmal · Jan M. Pestka · Peter Ogon · Norbert P. Südkamp · Philipp Niemeyer

Bode et al compare clinical outcome in patients with ACI and concomitant varus deformity of 1-5° with or without additional HTO in 43 patients, mean age 39 years.
Group A (n = 19) was treated with ACI and additional HTO; group B (n = 24) received ACI only.
Survival rate in terms of absence of the need of reintervention was defined as main outcome parameter.
• In the subgroup without reintervention, functional outcome (KOOS and WOMAC) was evaluated.
• Overall rate of reintervention was 12 (27.9 %).
They concluded that while there is general consensus for treating varus deformities of 5° or more in patients with cartilage lesions of the medial femoral condyle, HTO also leads to a reduced rate of reinterventions and longer survival rates in patients with varus deformities of 1-5°
• Survival was significantly higher in group A (OT plus ACI), 89.5 %, than in group B (ACI alone) 58.33 %; \( p = 0.023 \)

• Conclusion 1, ACI alone in presence of overload fails in 50% of the cases

• Conclusion 2, even minimal overload benefits from corrective OT!
Minas et al looked at their 10 years results of ACI in 210 patients, mean age 36, defect size 8.4 cm². At a mean of 12 ± 2 years follow up, 53 of 210 patients (25%) had at least one failed ACI graft.
Their goal was to normalize excessive stresses by Normoaxation Osteotomy rather than further unload the respective compartment, except in “kissing” weight bearing lesions, in which they overcorrected by $2^\circ$ to unload the defects.
Survivorship was higher in patients with concomitant high tibial osteotomy (HTO) versus no HTO ($p = 0.01$). They deliberately did not overcorrect by $3^\circ$ to $5^\circ$ as recommended by Coventry,

**Conclusion, ACI alone is worse than ACI plus OT**
Finally, we report the study of Harris et al who looked at a series of 35 osteotomies for lateral compartment chondral defects of the knee with 2 years follow up of cases in which unloading osteotomy was performed if the mechanical axis of the lower extremity preferentially loaded or overloaded the affected compartment.
• with no significant differences between isolated and combined surgery and a low rate of complications and reoperations.

• They concluded that in patients with lateral compartment focal chondral defects with or without lateral meniscal deficiency and valgus malalignment, surgical cartilage repair and correction of concomitant pathology can significantly improve clinical outcomes at 2-year follow-up
To summarize, there are more papers that we were unable to discuss here, but together with the selection presented,
there is solid evidence in literature that osteotomy is the \textit{real workhorse} in the cartilage repair setting (Citation W. Bugbee, 2016) and today, the majority of Cartilage Surgeons finally understand that.
But in many countries surgeons are still afraid of osteotomy or don’t know how to do it! Omission to correct the axes is in many instances responsible for failures of Cartilage Repair.
Still today, there are too many in our field, offering cartilage repair surgery without even looking at the patient’s axial alignment.
Osteotomy is like doing cartilage repair without cartilage repair!

(Citation A. Getgood)
Finally, we have learnt that in cases of cartilage repair and osteotomy, the degree of correction is individualized with normalization of alignment as a goal rather than the traditional overcorrection most commonly employed when treating medial compartment arthritis.

So, the conclusion would be to first, before talking Cartilage Repair, learn to plan and perform a safe osteotomy technique.
• For the first 19 years of its existence, ICRS did may be not care enough about these facts.
• In this patient population, do we have to realize that it based its right to be on a potential of only 6% improvement?
Thanks for listening to me!
Thanks for (finally) listening to me!
Finally we report the study of Harris et al who looked at a series of 35 osteotomies for lateral compartment chondral defects of the knee with 2 years follow up of cases in which unloading osteotomy was performed if the mechanical axis of the lower extremity preferentially loaded or overloaded the affected compartment.
Survival and clinical outcome of isolated high tibial osteotomy and combined biological knee reconstruction

Joshua D. Harris d, Ryan McNeilan a,b, Robert A. Siston a,b,c, David C. Flanigan a,b,*
Purpose: We sought to determine survival and clinical outcomes of high tibial osteotomy (HTO) with or without articular cartilage surgery and/or meniscal allograft transplantation in patients with medial compartment chondral pathology, varus malalignment, and/or meniscal deficiency, whether there is any difference in survival or clinical outcome between these patient cohorts, and whether there is any difference between opening-wedge (OWHTO) and closing-wedge (CWHTO) techniques.

Methods: A systematic review of multiple medical databases was performed using PRISMA guidelines. Study quality was assessed via modified Coleman Methodology Scores (MCMS).
Results: Sixty-nine studies were included (4557 subjects). MCMS rating was overall poor. Mean follow-up was 7.1 years. Mean subject age was 53 years. Survival of isolated HTO was 92.4%, 84.5%, 77.3%, and 72.3% at 5, 10, 15, and 20 years of follow-up. At 5 years of follow-up, HTO with articular cartilage surgery had significantly greater survival (97.7%) than either isolated HTO (92.4%) or HTO with MAT (90.9%). Isolated HTO, HTO with articular cartilage surgery, and HTO with MAT all significantly improved subjective and objective clinical outcome scores. At two years of follow-up, survival was significantly greater following OWHTO (98.7%) versus CWHTO (96.7%). However, at all other time points with or without combined articular cartilage surgery and/or MAT, there was no significant survival difference between the techniques.
Conclusions: Survival and clinical outcomes of isolated HTO were excellent at short- and mid-term follow-ups, but deteriorated with time. HTO with concomitant procedures also demonstrated excellent early survival and clinical outcomes that deteriorated with time (up to 10 years).
Fig. 1. HTO survival. Length of follow-up was different for all groups (up to 20 years for isolated HTO, up to 10 years for HTO + articular cartilage surgery, and up to 5 years for HTO + MAT). At five years follow-up, survival of HTO + cartilage surgery was significantly higher than isolated HTO (97.7% vs. 92.4%; p < 0.001; Z = 3.42).
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KSSTA (Knee Surgery, Sports Traumatology, and Arthroscopy); CORR (Clinical Orthopaedics & Related Research); JBJS-Am (Journal of Bone and Joint Surgery, American version); JBJS-Br (Journal of Bone and Joint Surgery, British version); JOS (Journal of Orthopaedic Surgery); AJSM (American Journal of Sports Medicine).
\(^a\) Three or fewer studies per journal included in this review.
Fig. 2. Survival comparison of OWHTO and CWHTO. Although length of follow-up was longer following CWHTO, there was no significant difference in survival between the two groups at the available comparative time points.
Nevertheless, mid-term follow-up (5 years) revealed significantly greater survival (97.7%) for HTO with articular cartilage surgery than either isolated HTO (92.4%) or HTO with MAT (90.9%).
Further, at two years follow-up, survival was significantly greater following OWHTO (98.7%) versus CWHTO (96.7%). However, at all other time points with or without combined articular cartilage surgery and/or MAT, there was no significant survival difference between the two techniques.
Radiographically, OWHTO increased posterior tibial slope and decreased patellar height, while CWHTO decreased posterior slope and increased patellar height. Although statistically significant findings were identified as above, the clinical difference is likely small.
However, the increased amount of surgery, either concurrently or staged, is not without limitation. Despite significantly improved outcomes and low rates of complications and failures, combined “biological knee reconstruction” surgery is associated with a high rate of re-operation.
Survivorship of isolated HTO
There were 4344 knees that underwent isolated HTO.
There were 399 and 113 knees that underwent combined HTO with articular cartilage surgery and MAT, respectively.
There was also a difference in length of follow-up for each group analyzed (isolated HTO mean 9.2 years; HTO+cartilage surgery mean 5.0 years; HTO+MAT mean 6.8 years).
1) What are the survival and clinical outcomes of HTO in patients with medial compartment OA and varus malalignment?

2) What are the survival and clinical outcomes of HTO and cartilage repair/restoration in patients with medial chondral defects and varus malalignment? and

3) What are the survival and clinical outcomes of HTO, and medial MAT in patients with medial OA, varus malalignment, and/or medial meniscal deficiency?
High Tibial Osteotomy: Indications, Techniques, and Postoperative Management

Abstract

Chadwick C. Prodromos, MD
Annunziato Amendola, MD
Roland P. Jakob, MD

AAOS
Instr Course lect 2015;64:555-565.
Microfracture With HTO
Although there are few data to guide treatment regarding microfracture with HTO, many surgeons routinely perform microfracture at the time of an HTO." Although HTO by itself has been associated with cartilage regeneration in the medial compartment without microfracture, the minimal added risk and reported good outcomes appear to justify the addition of this quick arthroscopic procedure at the time of HTO. Microfracture should not be performed in asymptomatic patellofemoral or lateral compartments to avoid inciting pain in these areas.
Cartilage Restoration Procedures
The literature has shown that results of autologous chondrocyte implantation are compromised by angular deformity toward the affected compartment
(varus for a medial lesion and valgus for a lateral lesion and logic healing is assured. procedure).
Any cartilage restoration procedure can be performed simultaneously with HTO, although such combined surgical procedures are long and difficult. The decision to stage or simultaneously perform the procedures depends on the preference of the patient and the experience of the treating surgeon.
No study has been found that compares prospectively OT vs Cartilage Repair in equally malaligned knees.
Equally, we do not find recommendations based on scientific evidence of how much deformity is still tolerated to safely perform Cartilage Repair alone without realignment.
Studies comparing OT alone vs OT+ do not confirm evidence that on long term the latter way offers superior follow up’s
OATS Experience
Minzlaff et al.\textsuperscript{23} reported on a group of 86 patients who underwent osteochondral autologous transfer (OAT) combined with valgus HTO. The mean follow-up was 7.5 years with mean survival rates of 95.2\% ± 2.7\% at 5 years, 93.2\% ± 3.3\% at 7 years, and 90.1\% ± 4.4\% at 8.5 years after surgery.

Using the Lysholm score for knee function they also observed a significant increase (from 40 to 73) following surgery and improvements in pain intensity.
we agree 100% osteotomy is the real workhorse in the cartilage repair setting

W. Bugbee, 2016
most of us are understanding that finally but here in the US people are still afraid of osteotomy or don't know how or why!
When someone asks me about why their patient "failed" the cartilage procedure they did I always ask about alignment and the response is usually silence. . . . .
Alan Getgood have this idea of someday doing a session entitled "Cartilage repair without cartilage repair"
Allograft Experience
In a clinical and histologic study of failed fresh osteochondral allografts, Oakeshott et al. observed a greater number of failures in grafts that were placed in compartments that had increased stress concentrations due to mechanical malalignment.

Their histologic study showed that grafts subjected to higher forces lead to a delay in revascularization, creeping substitution, and additional loss of articular cartilage.
Third, we did not have a comparison group which would include an allograft group with malalignment without concomitant osteotomy.
A comparison group of this sort would have allowed for a better understanding of the benefits of osteotomy in long term survival of grafts in allograft patients.
We conclude that combining opening wedge HTO and osteochondral allograft procedures in properly selected patients is safe and effective.

Bugbee
Duivenvoorden et al.\textsuperscript{10} reviewed 412 patients to compare the survivorship of patients undergoing opening versus closing wedge osteotomy for varus malalignment. The authors reported that although opening wedge osteotomy had a higher rate of adverse events, 10-year survival was higher (90\% vs 75\%) in comparison with closing wedge osteotomy.
In cases of cartilage repair and osteotomy the degree of correction is individualized with normalization of alignment often a goal rather than the overcorrection most commonly employed when treating medial compartment arthritis.

Marti Ch…
• Systematic literature review
• 69 Studies
• 4344 knees after isolated HTO
Survival and clinical outcome of isolated high tibial osteotomy and combined biological knee reconstruction

**Überlebensrate isolierte HTO:**

- 5 Jahre: 92%
- 10 Jahre: 85%
- 15 Jahre: 77%
- 20 Jahre: 72%

*Harris et al. (2013) Knee*