ISAKOS CONGRESS 2025 | MUNICH GERMANY June 8–11

Clinical Outcomes of High Tibial Osteotomy with Bone Marrow Stimulation Techniques in Knee Osteoarthritis: a Systematic Review

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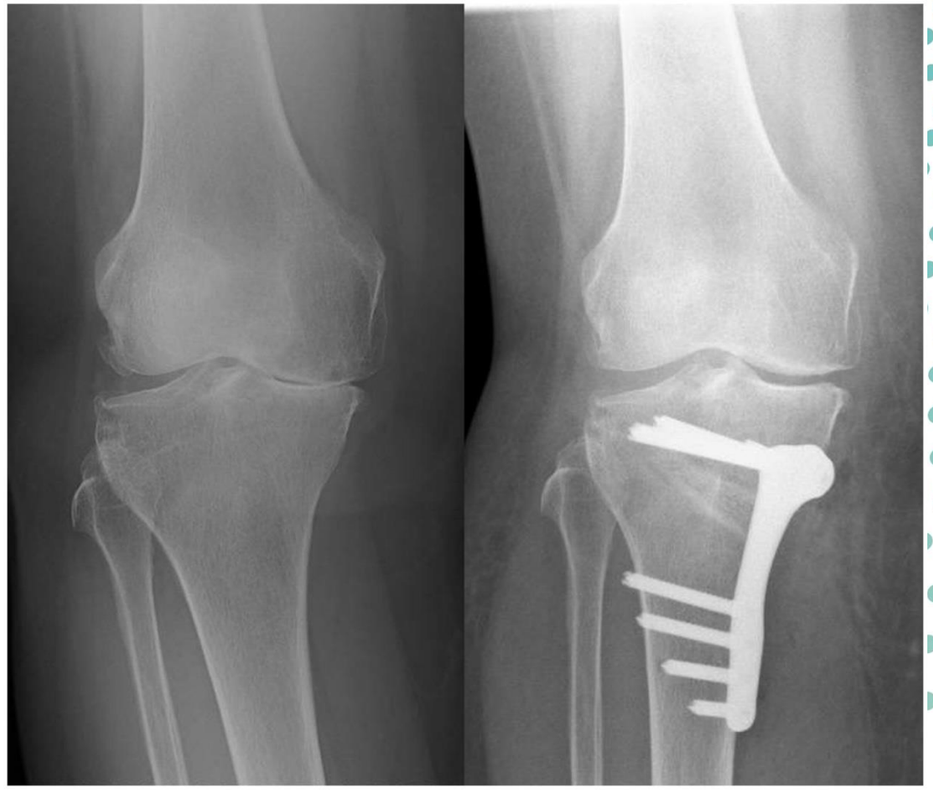
Faculty Disclosure Information

- No company affiliations or conflict of interest.

Background

- Knee OA - most common joint disease[1]
- Mechanically driven biological problem
  - inconsistent distribution of force[2]
  - wear and tear of cartilage → trigger inflammatory pathways[2]
- Correction of varus deformity
  → distributes force evenly[3]
  → addresses mechanical issue
- Cartilage regeneration[3,4]
  → addresses biological issue?

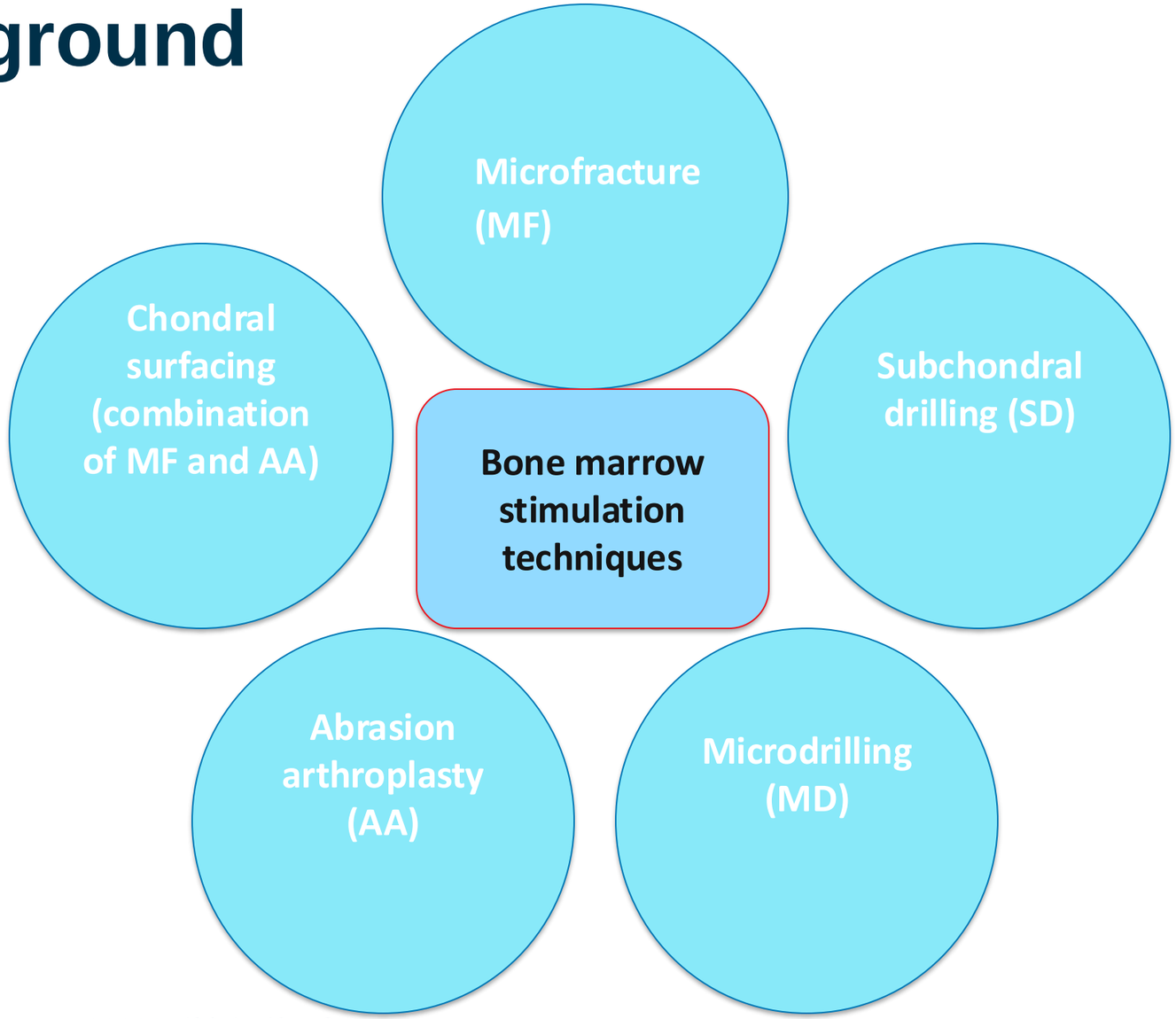


Background

Cartilage regeneration:

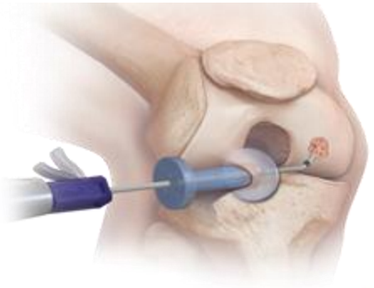
- Formal cartilage repair not recommended[10]
- Injections (PRP, BMAC, MSC etc) → heterogeneity[8,9]
- Osteochondral auto/allograft transplant → focal chondral defects[5,6]
- Autologous chondrocyte implantation → requires 2 surgeries, expensive[7]
- Bone marrow stimulation techniques?

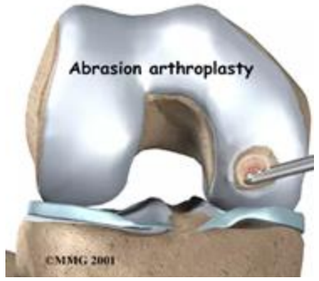
Background


Microfracture (MF)
Chondral surfacing (combination of MF and AA)
Bone marrow stimulation techniques
Subchondral drilling (SD)
Abrasion arthroplasty (AA)
Microdrilling (MD)

Aim

- To present an up-to-date summary of the clinical outcomes associated with HTO combined with BMST (microfracture, subchondral drilling, microdrilling, abrasion arthroplasty) in patients with knee osteoarthritis

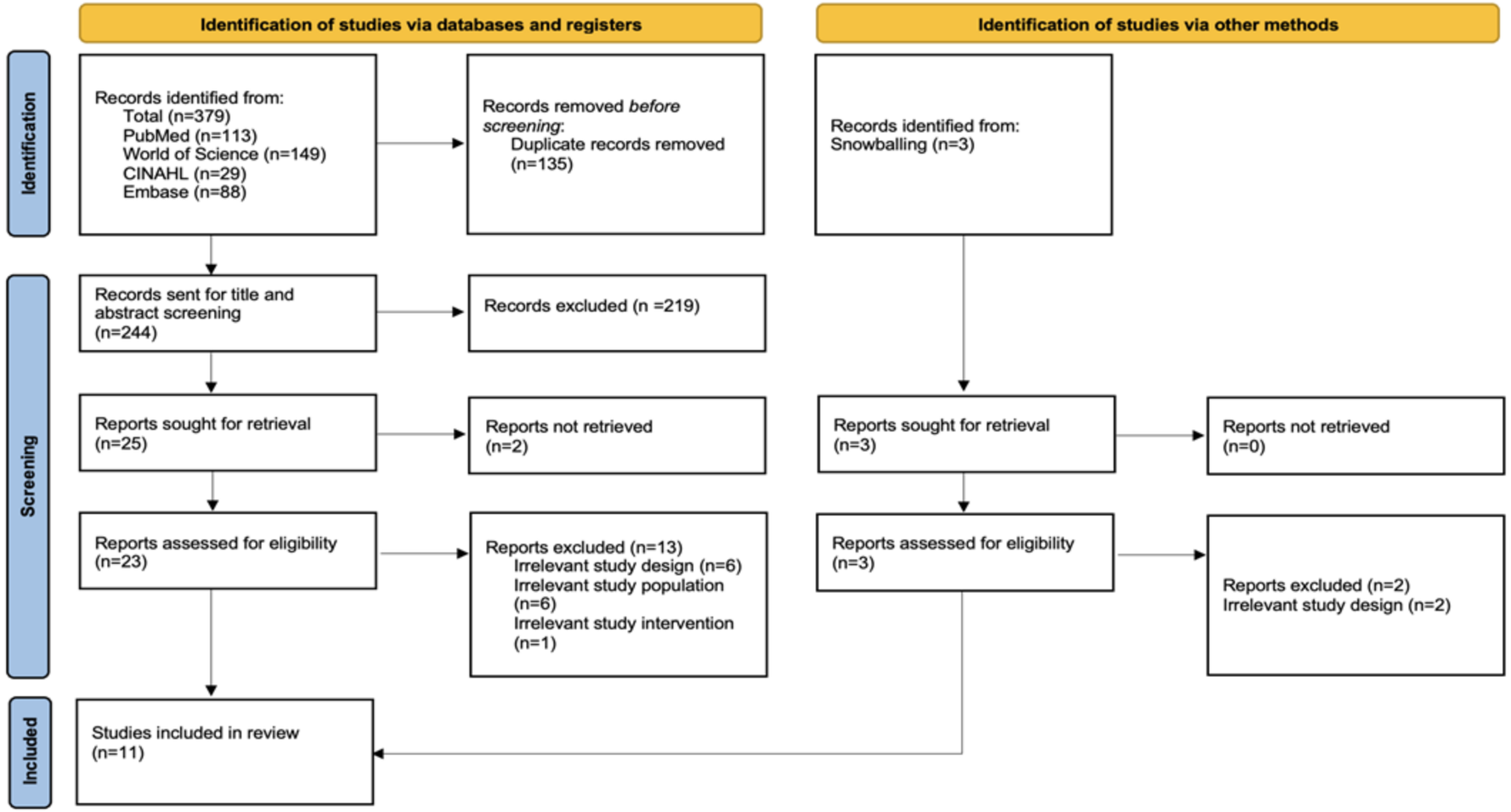




Materials & Methods

- Systematic Review
- Comprehensive database search of PubMed, Embase, Web of Science (WoS) and CINAHL from inception up to 3 March 2024
  - Inclusion Criteria
    - Follow-up studies (inception cohort studies/non-randomized controlled trials/retrospective cohort studies)
    - Case series that had more than 10 people
    - Studies that involved patients who underwent a combination of medial opening wedge high tibial osteotomy (OWHTO) and a bone stimulation technique
  - Exclusion Criteria
    - Systematic reviews, meta-analysis, case reports, case series involving less than 10 people
    - Articles where full text was unavailable
- Data extraction (study demographics, clinical outcomes)

Materials & Methods



Results

- Demographic data (n=516)
  - Mean age: 59 years
- Mean follow up time: 33 months
- BMST
  - MF (n=6), SD (n=1), MD (n=2), AA (n=1), chondral surfacing (n=1)
- Scoring systems
  - WOMAC (n=4), KOOS (n=3), Lysholm (n=2), IKDC (n=5), Tegner (n=1), KSS (n=4), VAS (n=2), HSS (n=1)
  - All above the MCID post procedure

Author year, country	Study design/level of evidence	Sample size/mean age (years)	Average follow up Period (months)	Outcomes reported
HTO + microfracture (MF)				
Souza et al 2018, Brazil(53)	Retrospective cohort study/level III	56/ 39.3	18	Lysholm
Lee et al 2019, South Korea(29)	Retrospective case control study/level III	57 / 57	24	WOMAC, KSS, ICRS
Bai et al 2023, China(7)	Retrospective case series/ Level IV	86/55.3	22.4	KSS, IKDC, ICRS
Kim et al 2017, South Korea(54)	Randomized Controlled Trial/Level II	14/55.7	12	IKDC, Tegner, VAS, KOOS, ICRS
Jin et al 2021, South Korea(30)	Retrospective cohort study/level III	43/55.8	43	KSS, WOMAC, IKDC, ICRS
Ferruzzi et al 2014, Italy(55)	Retrospective cohort study/level III	18 /53	18	WOMAC, HSS
HTO + Subchondral drilling (SD)				
Jung et al 2024, South Korea(56)	Retrospective case-control study/ Level III	33/59.9	24	Lysholm, IKDC, VAS, ICRS
HTO + Micro drilling (MD)				
Jung et al 2015, South Korea(14)	Retrospective case-control study/ Level III	61/61.5	24	KSS
Shon et al 2023, South Korea(31)	Retrospective cohort study/level III	51/55.3	24	WOMAC, KOOS, ICRS
HTO + abrasion arthroplasty (AA)				
Yamada et al 2021, Japan(6)	Case series/Level V	18/64	33	KOOS, ICRS
HTO + chondral surfacing (AA + MF)				
Schuster et al 2018, Germany(19)	Case series/Level IV	79/50.9	120	IKDC

MOWHTO=medial opening wedge high tibial osteotomy; MF=Microfracture; SD=Subchondral Drilling; MD= Microdrilling; AA=Abrasion Arthroplasty; WOMAC=Western Ontario McMaster Universities Arthritis Index; KSS=Knee Society Score (KSS); IKDC=International Knee Documentation Committee; VAS=Visual Analog scale; KOOS=Knee Injury and Osteoarthritis Outcome; HSS=Hospital for Special Surgery Knee-rating scale

Discussion

Pros of BMST	Cons of BMST
• Simpler, cheaper and more accessible[11,12] • Positive clinical outcomes above the MCID	• Additional cost, time, complexity (compared to HTO alone)[13] • Complications of each BMST[14-16]

HTO alone vs HTO with BMST

- HTO alone has good long term outcomes[17]
- Similar mean improvement in clinical scores (WOMAC, HHS, KSS)
- HTO with BMST better cartilage regeneration but similar clinical outcomes[18-19]

Limitations

- Small number of available studies (n=11)
- Few papers on MD/SD/AA
- Heterogenous reported clinical outcomes

Conclusion

- HTO with BMST has good clinical outcomes post operatively
- More comparative studies are needed to come to more definite conclusions on whether we should recommend HTO with BMST over an isolated HTO in the clinical setting
- Correlation between cartilage regeneration vs clinical outcomes

References

(1) Hsu H, Siwiec RM. Knee Osteoarthritis. [Updated 2023 Jun 26]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK507884/

(2) Yao Q, Wu X, Tao C, Gong W, Chen M, Qu M, et al. (2023) Osteoarthritis: pathogenic signaling pathways and therapeutic targets. Signal Transduction and Targeted Therapy 8:56

(3) Jung WH, Takeuchi R, Chun CW, Lee JS, Ha JH, Kim JH, et al. (2014) Second-look arthroscopic assessment of cartilage regeneration after medial opening-wedge high tibial osteotomy. Arthroscopy 30:72-79

(4) Lee DH, Kim SJ, Kim SA, Ju G-i (2022) Past, present, and future of cartilage restoration: from localized defect to arthritis. Knee Surgery & Related Research 34:1

(5) Aae TF, Randsborg PH, Lurås H, Årøen A, Lian Ø B (2018) Microfracture is more cost-effective than autologous chondrocyte implantation: a review of level 1 and level 2 studies with 5 year follow-up. Knee Surg Sports Traumatol Arthrosc 26:1044-1052

(6) Minas T (2016) ICRS Commentary on the Study by Knutsen et al. The journal of Bone and Joint Surgery

(7) Chimutengwende-Gordon, M., Donaldson, J., and Bentley, G. (2020). Current Solutions for the Treatment of Chronic Articular Cartilage Defects in the Knee. EFORT Open Rev. 5, 156–163. doi:10.1302/2058-5241.5.190031

(8) O'Connell B., Wragg N.M., Wilson S.L. The use of PRP injections in the management of knee osteoarthritis. Cell Tissue Res. 2019;376:143–152. doi: 10.1007/s00441-019-02996-x.

(9) Testa, G., Giardina, S. M. C., Culmone, A., Vescio, A., Turchetta, M., Cannavò, S., & Pavone, V. (2021). Intra-Articular Injections in Knee Osteoarthritis: A Review of Literature. Journal of functional morphology and kinesiology, 6(1), 15. https://doi.org/10.3390/jfmk6010015

(10) Brittberg, M., Gomoll, A. H., Canseco, J. A., Far, J., Lind, M., & Hui, J. (2016). Cartilage repair in the degenerative ageing knee. Acta orthopaedica, 87(sup363), 26–38. https://doi.org/10.1080/17453674.2016.1265877

(11) Aae TF, Randsborg PH, Lurås H, Årøen A, Lian Ø B (2018) Microfracture is more cost-effective than autologous chondrocyte implantation: a review of level 1 and level 2 studies with 5 year follow-up. Knee Surg Sports Traumatol Arthrosc 26:1044-1052

(12) Minas T (2016) ICRS Commentary on the Study by Knutsen et al. The journal of Bone and Joint Surgery

(13) Slabaugh M (2023) Editorial Commentary: Knee Cartilage Restoration Does Not Greatly Improve Clinical Outcomes After High Tibial Osteotomy-In the Short Term. Arthroscopy 39:2188-2190

(14) Orth P, Gao L, Madry H (2020) Microfracture for cartilage repair in the knee: a systematic review of the contemporary literature. Knee Surg SportsTraumatol Arthrosc 28:670-706

(15) Alam K, Khan M, Muhammad R, Qamar SZ, Silberschmidt VV (2015) In-vitro experimental analysis and numerical study of temperature in bone drilling. Technol Health Care 23:775-783

(16) Gill TJ, Steadman JR. Bone Marrow Stimulation Techniques: Microfracture, Drilling, and Abrasion. In: Cole BJ, Malek MM, eds. Articular Cartilage Lesions: A Practical Guide to Assessment and Treatment;10.1007/978-0-387-21553-2_7. New York, NY: Springer New York; 2004:63-72.

(17) Dal Fabbro G, Grassi A, Agostinone P, Lucidi GA, Fajury R, Ravindra A, et al. (2024) High survivorship rate and good clinical outcomes after high tibial osteotomy in patients with radiological advanced medial knee osteoarthritis: a systematic review. Archives of Orthopaedic and Trauma Surgery;10.1007/s00402-024-05254-0

(18) Akizuki S, Yasukawa Y, Takizawa T (1997) Does arthroscopic abrasion arthroplasty promote cartilage regeneration in osteoarthritic knees with eburnation? A prospective study of high tibial osteotomy with abrasion arthroplasty versus high tibial osteotomy alone. Arthroscopy 13:9-17

(19) Lee OS, Lee SH, Mok SJ, Lee YS (2019) Comparison of the regeneration of cartilage and the clinical outcomes after the open wedge high tibial osteotomy with or without microfracture: a retrospective case control study. BMC Musculoskeletal Disorders 20:267