Implant removal:
update searches and screening
for
Universitätsklinikum Schleswig-Holstein/Campus Kiel

Kleijnen Systematic Reviews Ltd

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1. PROJECT OBJECTIVES

A key aim of the research project "Making SDM a reality" is to inform patients as part of shared decision making (SDM).

Kleijnen Systematic Reviews (KSR) Ltd has prepared an evidence report with a synthesis of the evidence of treatment options for implant removal.

2. METHODS

Literature searches were conducted to identify systematic reviews and evidence-based guidelines about implant removal following osteosynthesis to update the 2019 evidence report. The search strategies were developed specifically for each database and the keywords adapted according to the configuration of each database. Searches were limited by date range for systematic reviews and guidelines from 2019-2021. Searches were not limited by language or publication status.

SEARCH SOURCES

Systematic reviews and guidelines

The following systematic review and health technology assessment specific databases were searched:

- Cochrane Database of Systematic Reviews (CDSR) (Wiley): 2019-2021/10/Iss10
- KSR Evidence (Internet) (https://ksrevidence.com/): 2019-2021/10/27
- Epistemonikos (Internet) (https://www.epistemonikos.org/): 2019-2021/11/13
- International HTA Database (INAHTA) (https://database.inahta.org/): 2019-2021/11/11

The following guidelines resources were searched:

- Guidelines International Network (GIN) (Internet) (https://www.g-i-n.net/home): 2019-2021/10/28
- NICE Evidence (Internet) (www.evidence.nhs.uk/): 2019-2021/10/29
- NICE Guidance (Internet) (https://www.nice.org.uk/guidance): 2019-2021/10/29
- ECRI Guidelines Trust (Internet) (https://guidelines.ecri.org/): 2019-2021/10/27
- Trip Database (https://www.tripdatabase.com/): 2019-2021/11/13
- Canadian Agency for Drugs and Technologies in Health (CADTH) (www.cadth.ca): 2019-2021/10/28

Full details of all search strategies are presented in Appendix 1.

Handling of citations

Identified references from the bibliographic database searches were downloaded into EndNote bibliographic management software for further assessment and handling.

Supplementary searches

The bibliographies of included review articles were also checked for additional relevant articles.

Prioritisation

During formal screening of titles and abstracts, studies were subject to a prioritisation process whereby the recency e.g., to most up-to-date clinical practice guidelines (CPG), methodological quality e.g., Cochrane systematic review (CSR), quality of the analyses per outcome (e.g., ratio of RCTs to observational studies), the number of included RCTs, the breadth of the timepoints reported etc. were considered to further prioritise which studies would be used to inform analyses. Studies were categorised into the following three categories: '1' = German, American, European or similar CPG; '2' = CSR or similar quality SR; '3' = potentially lower/other quality SR.

3. RESULTS

The original KSR searches were conducted on 12 and 13 March 2019; and of the 3,484 references screened, 11 studies were deemed eligible. In the current update, a total of 2,870 records were retrieved from the electronic literature searches (Appendix 1). After the removal of duplicate records, 2,216 titles and abstracts were screened by two reviewers. Hundred and thirty-three records were found to be potentially eligible and were longlisted after a consensus. Of those, five were short-listed and included in the analyses (Table 1).[1-5] See also Table 2 for an overview of primary studies included in the identified SRs/CPGs.

UPDATE – Concluding Assessment by SHARE-TO-CARE Evidence Team (07/07/22)

Based on the update searches conducted by KSR Ltd in October - November 2021, we want to highlight the following aspects: two recent systematic reviews (Agarwal et al., 2020; Kweh et al., 2021) address the issues of late onset infections and pre-planned removal, respectively, but neither use data from randomised clinical trials. Outcomes of biodegradable implants are discussed by Gareb et al. (2021), Sayum et al. (2021), and Leigheb et al. (2021), but the choice of implant material does not directly pertain to the question of implant removal or retention addressed by our decision aid.

Conclusion regarding the evidence report: No evidence update required. The present evidence report (November, 2019) remains valid until further notice.

Table 1 Evidence sources

Study/year	Evidence type	Primary studies	Number of studies	Intervention(s)	Comparator(s)	Outcome(s)	Date searched	Conclusions
Gareb 2021[1]	SR	RCT,OS	33	Biodegradable osteosyntheses	Titanium osteosyntheses	Efficacy of the fixation method	February 11, 2021	"Biodegradable osteosyntheses is a valid alternative to titanium osteosyntheses for orthognathic surgery, but with longer operation times"
Agarwal 2020[2]	SR	OS	49	Implant removal	Implant retention	Surgical site infections	2018	"[…] the key measure undertaken or implied by most authors to avoid risk of recurrence was removal or replacement of implants for late-onset surgical site infections"
Kweh 2021[3]	SR	RCT,non-RCT	13	Implant removal	Implant retention	Biomechanical and functional outcomes	May 2020	"In younger patients with thoracolumbar burst fractures who undergo posterior surgical stabilization, planned implant removal results in superior functional outcomes without significant difference in kyphotic angle correction loss compared to implant retention"
Sayum 2021[4]	SR	RCT	2	Biodegradable osteosyntheses	Metallic implants	Pain, function, adverse effects	January 2020	"Given the very low-quality evidence, we are uncertain […] whether biodegradable implants are better than metallic implants for

Study/year	Evidence type	Primary studies	Number of studies	Intervention(s)	Comparator(s)	Outcome(s)	Date searched	Conclusions
								displaced patellar fractures"
Leigheb 2021[5]	SR	RCT,OS,CR,CS	25	Biodegradable osteosyntheses	Metallic implants	Fracture union, re-operation, function, pain, toxicity, screw's biodegradability	June 5, 2020	"Therefore, an important future prospect could rely in the development of innovative hybrid systems aimed at fixing high load-bearing fractures, as well as in regenerative medicine by developing new magnesium-based engineered scaffolds."

* = refers to studies published after 2015.
AAOS = The American Academy of Orthopaedic Surgeons; CPG = clinical practice guideline; CR = case report; CS = case series; HTA = health technology assessment; OS = observational study; RCT = randomised controlled trial.

Table 2 Overview of primary studies included in the identified SRs

Study/year	Primary study(ies)	Reference (first author & journal)
Gareb 2021[1]	RCT*	1. Gareb B, Van Bakelen NB, Buijs GJ, Jansma J, De Visscher JGAM, Hoppenreijs TJM, et al. Comparison of the long-term clinical performance of a biodegradable and a titanium fixation system in maxillofacial surgery: a multicenter randomized controlled trial. PLoS One. 2017;12:1–12. 2. Norholt SE, Pedersen TK, Jensen J. Le Fort I miniplate osteosynthesis: a randomized, prospective study comparing resorbable PLLA/ PGA with titanium. Int J Oral Maxillofac Surg. 2004;33:245–52. 3. Tuovinen V, Suuronen R, Teittinen M, Nurmenniemi P. Comparison of the stability of bioabsorbable and titanium osteosynthesis materials for rigid internal fixation in orthognathic surgery. A prospective randomized controlled study in 101 patients with 192 osteotomies. Int J Oral Maxillofac Surg. 2010;39:1059–65. 4. Yu S, Bloomquist D. Can resorbable screws effectively be used in fixating bilateral sagittal split osteotomies for mandibular advancement? a randomized controlled trial. J Oral Maxillofac Surg. 2014;72:2273–7. 5. Stockmann P, Böhm H, Driemel O, Mühling J, Pistner H. Resorbable versus titanium osteosynthesis devices in bilateral sagittal split ramus osteotomy of the mandible -The results of a two centre randomised clinical study with an eight-year follow-up. J Cranio-Maxillofacial Surg. 2010;38:522–8.

Study/year	Primary study(ies)	Reference (first author & journal)
		6. Cheung LK, Chow LK, Chiu WK. A randomized controlled trial of resorbable versus titanium fixation for orthognathic surgery. Oral Surg Oral Med Oral Pathol Oral Radiol Endodontol. 2004;98:386–97. 7. Yoshioka I, Igawa K, Nagata J, Yoshida M, Ogawa Y, Ichiki T, et al. Comparison of material-related complications after bilateral sagittal split mandibular setback surgery: Biodegradable versus titanium miniplates. J Oral Maxillofac Surg. 2012;70:919–24. 8. Ueki K, Nakagawa K, Marukawa K, Takazakura D, Shimada M, Takatsuka S, et al. Changes in condylar long axis and skeletal stability after bilateral sagittal split ramus osteotomy with poly-l- lactic acid or titanium plate fixation. Int J Oral Maxillofac Surg. 2005;34:627–34. 9. Park J, Park Y. Postoperative stability of fixation with absorbables in simultaneous maxillomandibular orthognathic surgery. Maxillofac Plast Reconstr Surg. 2010;32:126–31. 10. Matthews NS, Khambay BS, Ayoub AF, Koppel D, Wood G. Preliminary assessment of skeletal stability after sagittal split mandibular advancement using a bioresorbable fixation system. Br J Oral Maxillofac Surg. 2003;41:179–84. 11. Cheung LK, Yip IHS, Chow RLK. Stability and morbidity of LeFort I osteotomy with bioresorbable fixation: a randomized controlled trial. Int J Oral Maxillofac Surg. 2008;37:232–41. 12. Buijs GJ, Van Bakelen NB, Jansma J, de Visscher JGAM, Hoppenreijs TJM, Bergsma JE, et al. A randomized clinical trial of biodegradable and titanium fixation systems in maxillofacial surgery. J Dent Res. 2012;91:299–304. 13. van Bakelen NB, Buijs GJ, Jansma J, de Visscher JG, Hoppenreijs TJ, Bergsma JE, et al. Comparison of biodegradable and titanium fixation systems in maxillofacial surgery: a two-year multi-center randomized controlled trial. J Dent Res. 2013;92:1100–5. 14. Van Bakelen NB, Vermeulen KM, Buijs GJ, Jansma J, De Visscher JGAM, Hoppenreijs TJM, et al. Cost-effectiveness of a biodegradable compared to a titanium fixation system in maxillofacial surgery: a multicenter randomized controlled trial. PLoS One. 2015;10:1–16.
Agarwal 2020[2]	OS	1. Chikawa T, Sakai T, Bhatia NN, et al. Retrospective study of deep surgical site infections following spinal surgery and the effectiveness of continuous irrigation. Br J Neurosurg. 2011;25:621-624. 2. Rathjen K, Wood M, McClung A, Vest Z. Clinical and radiographic results after implant removal in idiopathic scoliosis. Spine (Phila Pa 1976). 2007;32:2184-2188. 3. Gelalis ID, Arnaoutoglou CM, Politis AN, Batzaleksis NA, Katonis PG, Xenakis TA. Bacterial wound contamination during simple and complex spinal procedures. A prospective clinical study. Spine J. 2011;11:1042-1048. 4. Ahn DK, Park HS, Choi DJ, et al. The difference of surgical site infection according to the methods of lumbar fusion surgery. Clin Spine Surg. 2012;25:E230-E234.

Study/year	Primary study(ies)	Reference (first author & journal)
		5. Ishii M, Iwasaki M, Ohwada T, et al. Postoperative deep surgicalsite infection after instrumented spinal surgery: a multicenter study. Global Spine J. 2013;3:95-102. 6. Lee MJ, Cizik AM, Hamilton D, Chapman JR. Predicting surgical site infection after spine surgery: a validated model using a prospective surgical registry. Spine J. 2014;14:2112-2127. 7. Mazur MD, Sivakumar W, Riva-Cambrin J, Jones J, Brockmeyer DL. Avoiding early complications and reoperation during occipitocervical fusion in pediatric patients. J Neurosurg Pediatr. 2014; 14:465-475. 8. Nota SP, Braun Y, Ring D, Schwab JH. Incidence of surgical site infection after spine surgery: what is the impact of the definition of infection? Clin Orthop Relat Res. 2015;473:1612-1619. 9. Maruo K, Berven SH. Outcome and treatment of postoperative spine surgical site infections: predictors of treatment success and failure. J Orthop Sci. 2014;19:398-404. 10. Takizawa T, Tsutsumimoto T, Yui M, Misawa H. Surgical site infections caused by methicillin-resistant Staphylococcus epidermidis after spinal instrumentation surgery. Spine (Phila Pa 1976). 2017;42:525-530. 11. Miyazaki S, Kakutani K, Maeno K, et al. Surgical debridement with retention of spinal instrumentation and long-term antimicrobial therapy for multidrug-resistant surgical site infections after spinal surgery: a case series. Int Orthop. 2016;40:1171-1177. 12. Fang XT, Wood KB. Management of postoperative instrumented spinal wound infection. Chin Med J (Engl). 2013;126: 3817-3821. 13. Ahmed R, Greenlee JD, Traynelis VC. Preservation of spinal instrumentation after development of postoperative bacterial infections in patients undergoing spinal arthrodesis. J Spinal Disord Tech. 2012;25:299-302. 14. Yin D, Liu B, Chang Y, Gu H, Zheng X. Management of lateonset deep surgical site infection after instrumented spinal surgery. BMC Surg. 2018;18:121. 15. Ca´ceres AG, Jim´enez JL, Martı´n A´ R, Dura´n JM, Diaz BS, de Quevedo Puerta DG. Prognosis of deep infection in spinal surgery using implants, treated by retention, removal of bone graft and lengthy antibiotherapy. Rev Esp Cir Ortop Traumatol. 2019;63:7-11. 16. Ha KY, Kim YH. Postoperative spondylitis after posterior lumbar interbody fusion using cages. Eur Spine J. 2004;13:419-424. 17. Kim JI, Suh KT, Kim SJ, Lee JS. Implant removal for the management of infection after instrumented spinal fusion. J Spinal Disord Tech. 2010;23:258-265. 18. Croft LD, Pottinger JM, Chiang HY, Ziebold CS, Weinstein SL, Herwaldt LA. Risk factors for surgical site infections after pediatric spine operations. Spine (Phila Pa 1976). 2015;40:E112-E119.

Study/year	Primary study(ies)	Reference (first author & journal)
		19. Kuhns BD, Lubelski D, Alvin MD, et al. Cost and quality of life outcome analysis of postoperative infections after subaxial dorsal cervical fusions. J Neurosurg Spine. 2015;22:381-386. 20. Hedequist D, Haugen A, Hresko T, Emans J. Failure of attempted implant retention in spinal deformity delayed surgical site infections. Spine (Phila Pa 1976). 2009;34:60-64. 21. Di Silvestre M, Bakaloudis G, Lolli F, Giacomini S. Latedeveloping infection following posterior fusion for adolescent idiopathic scoliosis. Eur Spine J. 2011;20(suppl 1):S121-S127. 22. Kanayama M, Hashimoto T, Shigenobu K, Oha F, Togawa D. Effective prevention of surgical site infection using a Centers for Disease Control and Prevention guideline-based antimicrobial prophylaxis in lumbar spine surgery. J Neurosurg Spine. 2007; 6:327-329. 23. B´emer P, Corvec S, Tariel S, et al. Significance of Propionibacterium acnes-positive samples in spinal instrumentation. Spine (Phila Pa 1976). 2008;33:E971-E976. 24. ter Gunne AF, Mohamed AS, Skolasky RL, van Laarhoven CJ, Cohen DB. The presentation, incidence, etiology, and treatment of surgical site infections after spinal surgery. Spine (Phila Pa 1976). 2010;35:1323-1328. 25. Tempel Z, Grandhi R, Maserati M, et al. Prealbumin as a serum biomarker of impaired perioperative nutritional status and risk for surgical site infection after spine surgery. J Neurol Surg A Cent Eur Neurosurg. 2015;76:139-143. 26. Ramo BA, Roberts DW, Tuason D, et al. Surgical site infections after posterior spinal fusion for neuromuscular scoliosis: a thirtyyear experience at a single institution. J Bone Joint Surg Am. 2014;96:2038-2048. 27. Kabirian N, Akbarnia BA, Pawelek JB, et al. Deep surgical site infection following 2344 growing-rod procedures for early-onset scoliosis: risk factors and clinical consequences. J Bone Joint Surg Am. 2014;96:e128. 28. Watanabe M, Sakai D, Matsuyama D, Yamamoto Y, Sato M, Mochida J. Risk factors for surgical site infection following spine surgery: efficacy of intraoperative saline irrigation. J Neurosurg Spine. 2010;12:540-546. 29. Kanafani ZA, Dakdouki GK, El-Dbouni O, Bawwab T, Kanj SS. Surgical site infections following spinal surgery at a tertiary care center in Lebanon: incidence, microbiology, and risk factors. Scand J Infect Dis. 2006;38:589-592. 30. Maesani M, Doit C, Lorrot M, et al. Surgical site infections in pediatric spine surgery: comparative microbiology of patients with idiopathic and nonidiopathic etiologies of spine deformity. Pediatr Infect Dis J. 2016;35:66-70. 31. Nu´nez-Pereira S, Pellis´e F, Rodrı´guez-Pardo D, et al. Individualized antibiotic prophylaxis reduces surgical site infections by gram-negative bacteria in instrumented spinal surgery. Eur Spine J. 2011;20(suppl 3):397. 32. Labbe AC, Demers AM, Rodrigues R, Arlet V, Tanguay K, Moore DL. Surgical-site infection following spinal fusion: a case-control study in a children's hospital. Infect Control Hosp Epidemiol. 2003;24:591-595.

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		33. Boetto J, Chan-Seng E, Lonjon G, Pech J, Lotth´e A, Lonjon N. Is hospital information system relevant to detect surgical site infection? Findings from a prospective surveillance study in posterior instrumented spinal surgery. Orthop Traumatol Surg Res. 2015; 101:845-849. 34. Smith JS, Shaffrey CI, Sansur CA, et al. Rates of infection after spine surgery based on 108 419 procedures: a report from the Scoliosis Research Society Morbidity and Mortality Committee. Spine (Phila Pa 1976). 2011;36:556-563. 35. Maragakis LL, Cosgrove SE, Martinez EA, Tucker MG, Cohen DB, Perl TM. Intraoperative fraction of inspired oxygen is a modifiable risk factor for surgical site infection after spinal surgery. Anesthesiology. 2009;110:556-562. 36. Satake K, Kanemura T, Matsumoto A, Yamaguchi H, Ishikawa Y. Predisposing factors for surgical site infection of spinal instrumentation surgery for diabetes patients. Eur Spine J. 2013;22: 1854-1858. 37. Mackenzie WS, Matsumoto H, Williams BA, et al. Surgical site infection following spinal instrumentation for scoliosis: a multicenter analysis of rates, risk factors, and pathogens. J Bone Joint Surg Am. 2013;95:800-806,S1-S2. 38. Nu´n˜ez-Pereira S, Rodrı´guez-Pardo D, Pellis´e F, et al. Postoperative urinary tract infection and surgical site infection in instrumented spinal surgery: is there a link? Clin Microbiol Infect. 2014;20:768-773. 39. Manet R, Ferry T, Castelain JE, et al. Relevance of modified debridement-irrigation, antibiotic therapy and implant retention protocol for the management of surgical site infections: a series of 1694 instrumented spinal surgery. J Bone Jt Infect. 2018;3: 266-272. 40. Ploumis A, Mehbod AA, Dressel TD, Dykes DC, Transfeldt EE, Lonstein JE. Therapy of spinal wound infections using vacuumassisted wound closure: risk factors leading to resistance to treatment. J Spinal Disord Tech. 2008;21:320-323. 41. Hong HS, Chang MC, Liu CL, Chen TH. Is aggressive surgery necessary for acute postoperative deep spinal wound infection? Spine (Phila Pa 1976). 2008;33:2473-2478. 42. Falavigna A, Righesso O, Traynelis VC, Teles AR, da Silva PG. Effect of deep wound infection following lumbar arthrodesis for degenerative disc disease on long-term outcome: a prospective study. J Neurosurg Spine. 2011;15:399-403. 43. Mok JM, Guillaume TJ, Talu U, et al. Clinical outcome of deep wound infection after instrumented posterior spinal fusion: a matched cohort analysis. Spine (Phila Pa 1976). 2009;34: 578-583. 44. Caroom C, Tullar JM, Benton EG Jr, Jones JR, Chaput CD. Intrawound vancomycin powder reduces surgical site infections in posterior cervical fusion. Spine (Phila Pa 1976). 2013;38: 1183-1187.

Study/year	Primary study(ies)	Reference (first author & journal)
		45. Hikata T, Iwanami A, Hosogane N, et al. High preoperative hemoglobin A1c is a risk factor for surgical site infection after posterior thoracic and lumbar spinal instrumentation surgery. J Orthop Sci. 2014;19:223-228. 46. Ando M, Tamaki T, Yoshida M, et al. Surgical site infection in spinal surgery: a comparative study between 2-octylcyanoacrylate and staples for wound closure. Eur Spine J. 2014; 23:854-862. 47. Khanna K, Janghala A, Sing D, et al. An analysis of implant retention and antibiotic suppression in instrumented spine infections: a preliminary data set of 67 patients. Int J Spine Surg. 2018; 12:490-497. 48. Whitmore RG, Stephen J, Stein SC, et al. Patient comorbidities and complications after spinal surgery: a societal-based cost analysis. Spine (Phila Pa 1976). 2012;37:1065-1071. 49. Cizik AM, Lee MJ, Martin BI, et al. Using the spine surgical invasiveness index to identify risk of surgical site infection: a multivariate analysis. J Bone Joint Surg Am. 2012;94: 335-342.
Kweh 2021[3]	RCT,non-RCT	1. Chen L, Liu H, Hong Y, Yang Y, Hu L. Minimally Invasive Decompression and Intracorporeal Bone Grafting Combined with Temporary Percutaneous Short-Segment Pedicle Screw Fixation for Treatment of Thoracolumbar Burst Fracture with Neurological Deficits. World Neurosurg. 2020;135:e209-e220. 2. Ko S, Jung S, Song S, Kim JY, Kwon J. Long-term follow-up results in patients with thoracolumbar unstable burst fracture treated with temporary posterior instrumentation without fusion and implant removal surgery: Follow-up results for at least 10 years. Medicine. 2020;99(16):e19780. 3. Aono H, Ishii K, Takenaka S, et al. Risk factors for a kyphosis recurrence after short-segment temporary posterior fixation for thoracolumbar burst fractures. J Clin Neurosci. 2019;66: 138-143. 4. Aono H, Ishii K, Tobimatsu H, et al. Temporary short-segment pedicle screw fixation for thoracolumbar burst fractures: comparative study with or without vertebroplasty. Spine J. 2017; 17(8):1113-1119. 5. Chen JX, Xu DL, Sheng SR, et al. Risk factors of kyphosis recurrence after implant removal in thoracolumbar burst fractures following posterior short-segment fixation. Int Orthop. 2016;40(6): 1253-1260. 6. Chou PH, Ma HL, Liu CL, Wang ST, et al. Is removal of the implants needed after fixation of burst fractures of the thoracolumbar and lumbar spine without fusion? a retrospective evaluation of radiological and functional outcomes. Bone Joint Jl. 2016; 98-B(1):109-116. 7. Aono H, Tobimatsu H, Ariga K, et al. Surgical outcomes of temporary short-segment instrumentation without augmentation for thoracolumbar burst fractures. Injury. 2016;47(6):1337-1344. 8. Jeon CH, Lee HD, Lee YS, Seo JH, Chung NS. Is It Beneficial to Remove the Pedicle Screw Instrument After Successful Posterior Fusion of Thoracolumbar Burst Fractures? Spine (Phila Pa 1976). 2015;40(11):E627-633. 9. Ko SB, Lee SW. Result of posterior instrumentation without fusion in the management of thoracolumbar and lumbar unstable burst fracture. J Spin Disord Tech. 2014;27(4):189-195.

Study/year	Primary study(ies)	Reference (first author & journal)
		10. Kim HS, Kim SW, Ju CI, Wang HS, Lee SM, Kim DM. Implant removal after percutaneous short segment fixation for thoracolumbar burst fracture: does it preserve motion? J Korea Neurosurg Soc. 2014;55(2):73-77. 11. Toyone T, Ozawa T, Inada K, et al. Short-segment fixation without fusion for thoracolumbar burst fractures with neurological deficit can preserve thoracolumbar motion without resulting in post-traumatic disc degeneration: a 10-year follow-up study. Spine (Phila Pa 1976). 2013;38(17):1482-1490. 12. Yang H, Shi JH, Ebraheim M, et al. Outcome of thoracolumbar burst fractures treated with indirect reduction and fixation without fusion. Eur Spine J. 2011;20(3):380-386. 13. Xu BS, Tang TS, Yang HL. Long-term results of thoracolumbar and lumbar burst fractures after short-segment pedicle instrumentation, with special reference to implant failure and correction loss. Orthop Surg. 2009;1(2):85-93.
Sayum 2021[4]	RCT	1. Chen A, Hou C, Bao J, Guo S. Comparison of biodegradable and metallic tension-band fixation for patella fractures. 38 patients followed for 2 years. Acta Orthopaedica Scandinavica 1998;69(1):39-42. 2. Juutilainen T, Pätiälä H, Rokkanen P, Törmälä P. Biodegradable wire fixation in olecranon and patella fractures combined with biodegradable screws or plugs and compared with metallic fixation. Archives of Orthopaedics and Trauma Surgery 1995;114(6):319-23.
Leigheb 2021[5]	RCT,OS,CR,CS	1. Yu X, Zhao D, Huang S, et al. Biodegradable magnesium screws and vascularized iliac grafting for displaced femoral neck fracture in young adults. BMC Musculoskelet Disord 2015; 16: 329. 2. Modrejewski CP, Plaass C, Ettinger S, Caldarone F, Windhagen H, Stukenborg-Colsman C. Degradationsverhalten bioabsorbierbarer magnesium-implantate bei distalen metatarsale- 1-osteotomien im MRT. Fuß & Sprunggelenk 2015; 13: 156–61. 3. Wichelhaus A, Emmerich J, Mittlmeier T. A case of implant failure in partial wrist fusion applying magnesium-based headless bone screws. Case Rep Orthop. 2016: 7049130. 4. Biber R, Pauser J, Markus G, Bail H J. Magnesium-based absorbable metal screws for intra-articular fracture fixation. Case Rep Orthop 2016; 34: 2207-14. 5. Plaass C, Ettinger S, Son L, Koenneker S, Noll Y, Weizbauer A. Early results using a biodegradable magnesium screw for modified chevron osteotomies. J Orthop Res 2016; 34: 2207-14. 6. Leonhardt H, Franke A, McLeod N M H, Lauer G, Nowak A. Fixation of fractures of the condylar head of the mandible with a new magnesium-alloy biodegradable cannulated headless bone screw. Br J Oral Maxillofac Surg 2017; 55: 623-5. 7. Meier R, Panzica M. First results with a resorbable MGYREZ® compression screw in unstable scaphoid fractures show extensive bone cysts. Handchir Mikrochir Plast Chir 2017; 49: 37-41.

Study/year	Primary study(ies)	Reference (first author & journal)
		8. Grieve P, O'Carroll S, Albastaki O. Six cas de série de patients de Magnezix®. Une vis métallique absorbable pour la fixation de la fracture du carpe et des fusions entre les carpes. Hand Surg and Rehabil 2017; 36: 488-9. 9. Biber R, Pauser J, Bremb M, Bailab H J. Bioabsorbable metal screws in traumatology: a promising innovation. Trauma Case Reports 2017; 8: 11-5. 10. Gigante A, Setaro N, Rotini M, Finzi S S, Marinelli M. Intercondylar eminence fracture treated by resorbable magnesium screws osteosynthesis: a case series. Injury 2018; 49: S48-53. 11. Kose O, Turan A, Unal M, Acar B, Guler F. Fixation of medial malleolar fractures with magnesium bioabsorbable headless compression screws: short-term clinical and radiological outcomes in eleven patients. Arch Orthop Trauma Surg 2018; 138: 1069-75. 12. Acar B, Kose O, Turan A, Unal M, KatiY A, Guler F. Comparison of bioabsorbable magnesium versus titanium screw fixation for modified distal chevron osteotomy in hallux valgus. Biomed Res Int 2018; 21: 9. 13. Aktan C, Ertan M B, Turan A, Kose O. Fixation of small osteochondral fragments in a comminuted distal humerus fracture with magnesium bioabsorbable screws: a case report. Cureus 2018; 10: e3752. 14. Plaass C, von Falck C, Ettinger S, Sonnow L, Calderone F Weizbauer A. Bioabsorbable magnesium versus standard titanium compression screws for fixation of distal metatarsal osteotomies - 3 year results of a randomized clinical trial. J Orthop Sci 2018; 23: 321-7. 15. Acar B, Unal M, Turan A, Kose O. Isolated lateral malleolar fracture treated with a bioabsorbable magnesium compression screw. Cureus 2018; 10: e2539. 16. Lingling C, Zefeng L, Ming W, Wenhan H, Jin K, Dewei Z. Treatment of trauma-induced femoral head necrosis with biodegradable pure Mg screw-fixed pedicle iliac bone flap. J Orthop Translat 2019; 17: 133-137. 17. Klauser H. Internal fixation of three-dimensional distal metatarsal I osteotomies in the treatment of hallux valgus deformities using biodegradable magnesium screws in comparison to titanium screws. Foot Ankle Surg 2019; 25: 398-405. 18. Atkinson HD, Khan S, Lashgari Y, Ziegler A. Hallux valgus correction utilising a modified short scarf osteotomy with a magnesium biodegradable or titanium compression screws - a comparative study of clinical outcomes. BMC Musculoskelet Disord 2019; 20: 334. 19. Choo JT, Sheng Lai SH, Tang, CQY, Thevendran G.Magnesium-based bioabsorbable screw fixation for hallux valgus surgery - a suitable alternative to metallic implants. Foot Ankle Surg 2019; 25: 727-32. 20. Leonhardt H, Ziegler A, Lauer G, Franke A. Osteosynthesis of the mandibular condyle with magnesium-based biodegradable headless compression screws show good clinical results during a 1-year follow-up period. J Oral Maxillofac Surg 2020; 79: 637-43.

Study/year	Primary study(ies)	Reference (first author & journal)
		21. Turan A, Kati YA, Acar B, Kose O. Magnesium bioabsorbable screw fixation of radial styloid fractures: case report. J Wrist Surg 2020; 9: 150-5. 22. May H, Kati YA, Gumussuyu G, Emre TY, Unal M, Kose O. Bioabsorbable magnesium screw versus conventional titanium screw fixation for medial malleolar fractures. J Orthop Traumatol 2020; 21: 9. 23. Acar B, Kose O, Unal M, Turan A, Kati YA, Guler F. Comparison of magnesium versus titanium screw fixation for biplane chevron medial malleolar osteotomy in the treatment of osteochondral lesions of the talus. Eur J Orthop Surg Traumatol 2020; 30: 163-73. 24. Zhao D, Huang S, Lu F, Wang B, Yang L, Qin L. Vascularized bone grafting fixed by biodegradable magnesium screw for treating osteonecrosis of the femoral head. Biomaterials 2016; 81: 84-92. 25. Windhagen H, Radtke K, Weizbauer A, Diekmann J, Noll Y, Kreimeyer U. Biodegradable magnesium-based screw clinically equivalent to titanium screw in hallux valgus surgery: short term results of the first prospective, randomized, controlled clinical pilot study. Biomed Eng Online 2013; 12: 62.

* = only RCTs were extracted.
CPG = clinical practice guideline; CR = case report; CS = case series; OS = observational study; RCT = randomised controlled trial.

REFERENCES

[1] Gareb B, van Bakelen NB, Dijkstra PU, Vissink A, Bos RRM, van Minnen B. Efficacy and morbidity of biodegradable versus titanium osteosyntheses in orthognathic surgery: a systematic review with meta-analysis and trial sequential analysis. *Eur J Oral Sci* 2021;129(5):e12800.

[2] Agarwal A, Kelkar A, Jayaswal D, Schultz C, Goel VK, Agarwal AK, et al. Implant retention or removal for management of surgical site infection after spinal surgery. *Global Spine J.* 2020;10(5):640-6.

[3] Kweh BTS, Tan T, Lee HQ, Hunn M, Liew S, Tee JW. Implant removal versus implant retention following posterior surgical stabilization of thoracolumbar burst fractures: a systematic review and meta-analysis. *Global Spine J* 2021;Epub 2021 April 29.

[4] Sayum FJ, Lenza M, Tamaoki MJS, Matsunaga FT, Belloti JC. Interventions for treating fractures of the patella in adults. *Cochrane Database Syst Rev* 2021, Issue 2. Art. No.: CD009651. DOI: 10.1002/14651858.CD009651.pub3

[5] Leigheb M, Veneziano M, Tortia R, Bosetti M, Cochis A, Rimondini L, et al. Osteosynthesis devices in absorbable magnesium alloy in comparison to standard ones: a systematic review on effectiveness and safety. *Acta Biomed* 2021;92(S3):e2021025.

APPENDIX 1: SEARCH STRATEGIES

Table 3. Systematic reviews and guideline search results

Database	Dates	Results
CDSR	2019-2021/10/Iss10	41
CDSR Protocols	2019-2021/10/Iss10	13
KSR Evidence	2019-2021/10/27	1610
Epistemonikos	2019-2021/11/13	871
INAHTA	2019-2021/11/11	96
NICE	2019-2021/10/27	9
ECRI	2019-2021/10/27	30
NICE Evidence	2019-2021/10/29	185
CADTH	2019-2021/10/28	1
TRIP	2019-2021/11/13	8
GIN	2019-2021/10/28	6
Total		**2870**
Total after de-duplication		**2216**

Cochrane Database of Systematic Reviews (CDSR): 2019-2021/10/Iss10
Searched: 27.10.21

#1 MeSH descriptor: [Fracture Fixation, Internal] explode all trees 1453
#2 (Osteosynthesis or Osteosyntheses or gleitosteosynthesis or “osteo synthesis”) 1243
#3 (bone* or fracture*) near/2 (device* or hardware or implant* or fix* or pin or pins or pinned or pinning or nail* or screw* or plate* or reduction* or wire* or anchor*) 7094
#4 intramedullary near/2 nailing* 676
#5 MeSH descriptor: [Internal Fixators] explode all trees 1786
#6 Internal near/2 (Fixator* or fixation*) 2740
#7 ((device* or hardware or implant* or pin or pins or nail* or screw* or plate* or wire* or anchor*) near/2 remov*) 2035
#8 MeSH descriptor: [Device Removal] explode all trees 439
#9 #1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 with Cochrane Library publication date Between Jan 2019 and Oct 2021 3430

CDSR retrieved 41
CDSR protocols retrieved 13

KSR Evidence: 2019-2021/10/27
https://ksrevidence.com/
Searched: 27.10.21

1 (Osteosynthesis or Osteosyntheses or gleitosteosynthesis or "osteo synthesis") in All text 161 results

2 (fracture* or bone*) and (device* or hardware or implant* or pin or pins or pinned or pinning or nail* or screw* or plate* or wire* or anchor*) in All text 2437 results
3 (remov*) and (device* or hardware or implant* or pin or pins or nail* or screw* or plate* or wire* or anchor*) in All text 777 results
4 (Internal Fixator* or Internal fixation*) in All text 494 results
5 #4 or #3 or #2 or #1 in All text 1610 results
Filtered by: PUBLICATION DATE 2022, 2021, 2020, 2019

Epistemonikos (Internet): 2019-2021/11/13
https://www.epistemonikos.org/en/
Searched: 13.11.21

Limits 2019-2021, SR only, No Cochrane reviews

(title:((Osteosynthesis OR Osteosyntheses OR gleitosteosynthesis OR "osteo synthesis")) OR abstract:((Osteosynthesis OR Osteosyntheses OR gleitosteosynthesis OR "osteo synthesis"))) OR (title:((fracture* AND (device* OR hardware OR implant* OR pin OR pins OR pinned OR pinning OR nail* OR screw* OR plate* OR wire* OR anchor*))) OR abstract:((fracture* AND (device* OR hardware OR implant* OR pin OR pins OR pinned OR pinning OR nail* OR screw* OR plate* OR wire* OR anchor*)))) OR (title:((remov* AND (device* OR hardware OR implant* OR pin OR pins OR nail* OR screw* OR plate* OR wire* OR anchor*))) OR abstract:((remov* AND (device* OR hardware OR implant* OR pin OR pins OR nail* OR screw* OR plate* OR wire* OR anchor*))))

Records found = 871

International HTA Database (INAHTA): up to 2021/11/11
https://database.inahta.org/
Searched: 11.11.21

(("Fracture Fixation"[mhe] or "Internal Fixators"[mhe] or "Device Removal"[mhe])) OR ((Osteosynthesis or Osteosyntheses or gleitosteosynthesis or “osteo synthesis”)) OR ((bone* or fracture* or remov*) and (device* or hardware or implant* or fix* or pin or pins or pinned or pinning or nail* or screw* or plate* or reduction* or wire* or anchor*))

Limited: 2019-2021

Hits retrieved 96

National Institute for Health and Care Excellence (NICE): Guidelines: 2019-2021/10/27
https://www.nice.org.uk/
Searched 27.10.21

Keyword search then screened for 2019-C and relevancy.

Keywords	**Hits**

Osteosynthesis OR Osteosyntheses	0
Fracture OR fractures	9/93
Implant removal	0/29
Device removal	0/63
Total	**9**

ECRI Institute Guidelines Trust (Internet): 2019-2021/10/27
https://guidelines.ecri.org/
Searched: 27.10.21

Keywords	Hits
'fracture OR fractures OR Osteosynthesis OR Osteosyntheses'	30
Total	**30**

NICE Evidence Search: limited to guidance and SRs only (Internet): 2019-2021/10/29
https://www.evidence.nhs.uk/
Searched: 29/10/21

Keywords	Results limits to guidance and SRs (1/1/2019-29/10/21)
Osteosynthes*	1
fracture* and (device* or hardware or implant* or pin or pins or pinned or pinning or nail* or screw* or plate* or wire* or anchor*)	184
Total	**185**

Canadian Agency for Drugs and Technologies in Health (CADTH): 2019-2021/10/28
https://www.cadth.ca/
Searched: 28.10.21

Contains any words	Hits
Osteosynthesis	0
Osteosyntheses	0

Fracture	1/14
fractures	0/14
Total	**1**

TRIP (Internet): 2019-2021/11/13
https://www.tripdatabase.com
Searched: 13.11.21

Keywords	**Results limits to guidelines (limits: from 2019)**
osteosynthes*	5
fracture* and (device* or hardware or implant* or pin or pins or pinned or pinning or nail* or screw* or plate* or wire* or anchor*)	3
Total	**8**

Guidelines International Network (GIN): 2019-2021/10/28
https://www.g-i-n.net/home
Searched: 28.10.21

Keywords	**Hits**
Osteosynthesis	1
Osteosyntheses	0/1
Fracture	5
fractures	0/5
Total	**6**