

[6] Bistolfi A, Massazza G, Verné E, Massè A, Deledda D, Ferraris S, et al. Antibiotic-loaded cement in orthopedic surgery: a review. *ISRN Orthop.* 2011;2011:290851. doi:10.5402/2011/290851.

[7] Bohm E, Zhu N, Gu J, de Guia N, Linton C, Anderson T, et al. Does adding antibiotics to cement reduce the need for early revision in total knee arthroplasty? *Clin Orthop Relat Res.* 2014;472:162–168. doi:10.1007/s11999-013-3186-1.

[8] Hinarejos P, Guirro P, Leal J, Montserrat F, Pelfort X, Sorli ML, et al. The use of erythromycin and colistin-loaded cement in total knee arthroplasty does not reduce the incidence of infection: a prospective randomized study in 3,000 knees. *J Bone Joint Surg Am.* 2013;95:769–774. doi:10.2106/JBJS.L.00901.

[9] Yi Z, Bin S, Jing Y, Zongke Z, Pengde K, Fuxing P. No decreased infection rate when using antibiotic-impregnated cement in primary total joint arthroplasty. *Orthopedics.* 2014;37:839–845. doi:10.3928/01477447-20141124-07.

[10] Zhou Y, Li L, Zhou Q, Yuan S, Wu Y, Zhao H, et al. Lack of efficacy of prophylactic application of antibiotic-loaded bone cement for prevention of infection in primary total knee arthroplasty: results of a meta-analysis. *Surg Infect.* 2015;16:183–187. doi:10.1089/sur.2014.044.

[11] Nikitovic M. Antibiotic-laden bone cement for primary knee arthroplasty: a rapid review. Toronto ON: Health Quality Ontario; 2013;Nov;1–22.

[12] Cummins JS, Tomek IM, Kantor SR, Furnes O, Engesaeter LB, Finlayson SRG. Cost-effectiveness of antibiotic-impregnated bone cement used in primary total hip arthroplasty. *J Bone Joint Surg Am.* 2009;91:634–641. doi:10.2106/JBJS.G.01029.

[13] Jiranek WA, Hanssen AD, Greenwald AS. Antibiotic-loaded bone cement for infection prophylaxis in total joint replacement. *J Bone Joint Surg Am.* 2006;88:2487–2500. doi:10.2106/JBJS.E.01126.

[14] Morris AM, Gollish J. Arthroplasty and postoperative antimicrobial prophylaxis. *CMAJ.* 2016;188(4):243–244. doi:10.1503/cmaj.150429.

[15] Namba RS, Inacio MCS, Paxton EW. Risk factors associated with deep surgical site infections after primary total knee arthroplasty: an analysis of 56,216 knees. *J Bone Joint Surg Am.* 2013;95:775–782. doi:10.2106/JBJS.L.00211.

[16] Dale H, Hallan G, Hallan G, Espehaug B, Havelin LI, Engesaeter LB. Increasing risk of revision due to deep infection after hip arthroplasty. *Acta Orthop.* 2009;80:639–645. doi:10.3109/1745367090903506658.

[17] Malchau H, Herberts P, Ahnfelt L. Prognosis of total hip replacement in Sweden. Follow-up of 92,675 operations performed 1978–1990. *Acta Orthop Scand.* 1993;64:497–506.

[18] Parvizi J, Saleh KJ, Ragland PS, Pour AE, Mont MA. Efficacy of antibiotic-impregnated cement in total hip replacement. *Acta Orthop.* 2008;79:335–341. doi:10.1080/17453670710015229.

[19] Parvizi J, Gehrke T, Chen AF. Proceedings of the International Consensus on Periprosthetic Joint Infection. *Bone Joint J.* 2013;95-B:1450–1452. doi:10.1302/0301-620X.95B1.33135.

[20] Fleischman AN, Parvizi J. Rethinking the role of antibiotics in bone cement. *Orthopaedics Today.* August 2016. <https://www.healio.com/orthopedics/infection/news/print/orthopedics-today/%7be06ac19a-61e2-4264-b912-1b73ad6c4655%7d/rethinking-the-role-of-antibiotics-in-bone-cement>. Accessed August 31, 2018.

[21] Engesaeter LB, Espehaug B, Lie SA, Furnes O, Havelin LI. Does cement increase the risk of infection in primary total hip arthroplasty? Revision rates in 56,275 cemented and uncemented primary THAs followed for 0–16 years in the Norwegian Arthroplasty Register. *Acta Orthop.* 2006;77:351–358. doi:10.1080/17453670610046235.

[22] Engesaeter LB, Lie SA, Espehaug B, Furnes O, Vollset SE, Havelin LI. Antibiotic prophylaxis in total hip arthroplasty: effects of antibiotic prophylaxis systematically and in bone cement on the revision rate of 22,170 primary hip replacements followed 0–14 years in the Norwegian Arthroplasty Register. *Acta Orthop Scand.* 2003;74:644–651. doi:10.1080/00016470310018135.

[23] Espehaug B, Engesaeter LB, Havelin LI, Langeland N. Antibiotic prophylaxis in total hip arthroplasty. Review of 10,905 primary cemented total hip replacements reported to the Norwegian arthroplasty register, 1987 to 1995. *J Bone Joint Surg Br.* 1997;79:590–595.

[24] Wang J, Zhu C, Cheng T, Peng X, Zhang W, Qin H, et al. A systematic review and meta-analysis of antibiotic-impregnated bone cement use in primary total hip or knee arthroplasty. *PLoS One.* 2013;8:e82745. doi:10.1371/journal.pone.0082745.

[25] Sprowsen AP, Jensen C, Chambers S, Parsons NR, Aradhyula NM, Carluke I, et al. The use of high-dose dual-impregnated antibiotic-laden cement with hemiarthroplasty for the treatment of a fracture of the hip: the fractured hip infection trial. *Bone Joint J.* 2016;98-B:1534–1541. doi:10.1302/0301-620X.98B1.34693.

[26] Kleppel D, Stirton J, Liu J, Ebraheim NA. Antibiotic bone cement's effect on infection rates in primary and revision total knee arthroplasties. *World J Orthop.* 2017;8:946–955. doi:10.5312/wjo.v8.i12.946.

[27] Duquín TR, Jacobson JA, Schleck CD, Larson DR, Sanchez-Sotelo J, Morrey BF. Triceps insufficiency after the treatment of deep infection following total elbow replacement. *Bone Joint J.* 2014;96-B:82–87. doi:10.1302/0301-620X.96B1.31127.

[28] Hansen EN, Adeli B, Kenyon R, Parvizi J. Routine use of antibiotic laden bone cement for primary total knee arthroplasty: impact on infecting microbial patterns and resistance profiles. *J Arthroplasty.* 2014;29:1123–1127. doi:10.1016/j.arth.2013.12.004.



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### QUESTION 3: Does previous surgery (arthroscopic, fracture fixation, other non-arthroplasty) increase the risk of subsequent elbow periprosthetic joint infection (PJI) after total elbow arthroplasty (TEA)?

**RECOMMENDATION:** There is an apparent increase in the percentage of infections among patients with a previous operation in the affected elbow joint, though the association is not robust and needs to be further analyzed.

**LEVEL OF EVIDENCE:** Limited

**DELEGATE VOTE:** Agree: 100%, Disagree: 0%, Abstain: 0% (Unanimous, Strongest Consensus)

### RATIONALE

A comprehensive literature search of three online databases (PubMed/Medline, the Cochrane database for clinical trials, and Embase) was performed using the following MeSH search terms: “elbow,” “elbow joint,” “joint prosthesis,” “arthroplasty,” “replacement,” “elbow replacement,” “elbow arthroplasty” and “elbow prosthesis.”

Because of the evolution of TEA techniques, only articles published from January 2000 until September 2018 were reviewed. By the titles and abstracts, two reviewers independently identified potentially relevant articles for review of the full text. The reference lists of the included articles were manually checked to avoid missing relevant articles. When the entire text was obtained, the authors independently selected articles. Studies were not blinded for author, affiliation or source.

### Inclusion and Exclusion Criteria

The included articles presented original data on patients who had undergone TEA. The diagnoses included the following indications: osteoarthritis, trauma/fracture, post-traumatic osteoarthritis, rheumatoid arthritis, hemophilia and other inflammatory diseases. Studies with a minimum duration of follow-up of two years and a minimum of five patients were included. Studies on revision operations were not included. Articles presenting the results of both revision and primary TEA were excluded unless the information for primary TEA could be extracted. Articles presenting the results for interposition arthroplasties, fully-hinged prostheses, hemiarthroplasty or partial resurfacing of the elbow were reviewed if they included information regarding the outcome of further treatment

with TEA with extractable outcome data. Review articles, expert opinions and surgical technique articles were excluded. When possible, studies comparing different groups were analyzed separately. The search was restricted to articles written in English, Spanish and French. Some articles that represent institutional historical databases were included only once.

### Data Extraction

After the initial assessment for inclusion, two reviewers extracted data from the included articles. The primary goal was to determine the rate of infection after TEA and the pathogen responsible for determining the best potential antibiotic regimen.

The following parameters were recorded when available: numbers of patients and elbows, sex, age, design of TEA implant, indication for TEA (e.g., primary osteoarthritis, rheumatoid arthritis, fracture, post-traumatic osteoarthritis or other abnormality), whether the prosthesis was linked or unlinked, the rate of infection and the pathogen responsible. When prophylactic antibiotics were reported, they were recorded. Specific information regarding previous operations prior to arthroplasty was searched, as it was the focus of this review.

No other attempt was made to extract other data regarding other complications. Data regarding the number and type of surgical procedures before index TEA was collected and outcomes of these TEAs were extracted when available. Revision for infection was defined as removal of all or part of the arthroplasty or loosening that required removal regardless of the indication, or if a new TEA was implanted or excised.

### Data and Statistical Analysis

Different groups were established by the preoperative regimen and the causative pathogen, when known. The outcome measures were the rate of infection and the distribution according to the pathogen. When sensitivity antibiotic analysis was performed, this information was also analyzed.

### Methodological Quality

The two authors assigned the methodological quality of included studies according to the Center for Evidence-Based Medicine [1].

## RESULTS

### Articles

After the removal of duplicate articles, our initial search yielded 227 articles from Medline, Embase and Google Scholar. After title and abstract evaluation, a list of 56 articles was created for full review. After a full review, 35 studies were deemed suitable for further assessment and data collection.

There were no prospective case series and no randomized controlled trials. All were level IV evidence. Data were extracted into a standard worksheet for further analysis.

### Prior procedures

Reporting of previous surgery before TEA was only available in six studies. Two hundred and one patients out of 291 (69%) were reported to have had prior surgery before TEA. The average rate of infection in these six studies was 11%, which is almost double to the reported rate of 5.5% in our concurrent systematic review (Table 1).

Kodde et al. reported on a series of 17 patients treated for post-traumatic arthritis with a cemented semi-constrained prosthesis,

with a mean follow-up of 32 months. Fourteen patients had a prior operation consisting mainly in open reduction and internal fixation (nine cases, 64%), two patients had radial head resection, two had radial head prostheses implantation and one case had a medial epicondyle resection [2]. There was one case of infection (1%), but information is lacking regarding to which group it pertained. Additionally, the follow-up was short so that longer follow-up could increase the described rate of infection.

Baksi et al. reported on the use of a sloppy-hinge TEA for the treatment of fresh elbow fractures and non-unions. Eleven of the 41 cases reported had a previous failed internal fixation [3]. One of these patients suffered an infection that was treated with resection arthroplasty (1%) compared to one infection in 30 cases that did not undergo prior procedures (0.03%).

Throckmorton et al. reported on 84 patients with post-traumatic arthritis undergoing a semi-constrained TEA with a mean follow-up of nine years. The majority of this group of patients (90%) had prior surgery and the authors report seven deep infections without further information regarding the risk of preoperative surgery. The mean number of preoperative surgeries was three, so this group of patients may not be comparable to other studies [4].

Cil et al. reported the outcomes of a semi-constrained TEA for post-traumatic arthritis in 92 patients, of which 76 had previous surgery [5]. Of note, eight patients had a history of prior infection. At latest follow-up, five patients had an infection, all of which had had a previous operation. Interestingly, three of these patients had had a previous infection, so it is difficult to interpret if these were indeed a new episode or a reactivation of a latent infection.

Peden et al. reported on the outcome for TEA for an ankylosed or fused elbow, reporting 3 infections out of 13 cases [6]. One occurred perioperatively and the other happened at 2 and 15 years. Two of the three cases had previous surgery, but the type of surgery is not explicitly stated.

Sorbie et al. reported on a series of 44 unlinked TEA for hemophilic arthritis, rheumatoid arthritis or posttraumatic arthritis [7]. Sixteen patients had had a previous operation in the elbow and one of the seven infections occurred in a patient with post-traumatic arthritis and history of a previous operation. Once more, no reference to the number or type of previous operations was provided.

In a landmark paper, Morrey et al. reported on the outcome of 14 patients with an infection after TEA out of a group of 156 patients (9%) [8]. The rate of infection was 8 out of 99 patients without previous surgery compared to 6 out of 49 patients that had prior surgery (8% vs. 12.2%). This relationship was not statistically significant, alone. If only patients with previous surgery and rheumatoid arthritis were analyzed, the authors found a significant association, but the number of patients is so small that these findings should be interpreted with caution. Additionally, two of the patients with rheumatoid arthritis and prior surgery were on steroids.

The authors defined infection as deep sepsis that included different clinical and laboratory findings.

### Conclusions

There is insufficient information regarding the influence of previous surgery on the incidence of infection after total elbow arthroplasty. Inadequate reporting regarding the number of procedures, the type of procedures and other patient-associated factors makes achieving definitive conclusions difficult. In a landmark paper, Morrey et al. highlighted the association of prior operation with the development of a periprosthetic joint infection after TEA. However, even though there is an apparent increase in the percentage of infections among patients with a previous operation, the association is not robust and needs to be further analyzed.

**TABLE 1. Summary of information regarding the rate of infection after TEA when having prior surgery**

Author, Year	Indication	Arthroplasty	Number of Cases	Number of Infections	% Infection	Number of Previous Surgeries	Additional Information
Kodde et al., 2013	PT	Coonrad-Morrey	17	1	5.8	14	None
Baksi et al., 2011	PT	Baksi sloppy hinge	41	2	4.9	11	1 infection in 11 PTs w/ prior surgery vs. 1/30 w/o prior surgery
Throckmorton et al., 2010	PT	Coonrad-Morrey	84	7	8.3	76	None
Sorbie et al., 2011	RhA/ PT/ Hemophilia	Sorbie	44	7	17%	16	1 infection with prior surgery (PT)/ 6 had infection immuno-suppression (RhA)
Peden et al., 2009	10 PT/ 3 RhA	Coonrad-Morrey	13	3	23%	8	2 of 3 infected had prior surgery
Cil et al., 2008	PT	Coonrad-Morrey	92	5	5.4	76	All 5 infections had prior surgery (3 had infection prior to index TEA)

PT, post-traumatic; RhA, rheumatoid arthritis; TEA, total elbow arthroplasty

## REFERENCES

- [1] OCEBM Levels of Evidence. CEBM 2016. <https://www.cebm.net/2016/05/cebm-levels-of-evidence>. Accessed August 31, 2018.
- [2] Kodde IF, van Riet RP, Eggenraad D. Semiconstrained total elbow arthroplasty for posttraumatic arthritis or deformities of the elbow: a prospective study. *J Hand Surg*. 2013;38:1377-1382. doi:10.1016/j.jhsa.2013.03.051.
- [3] Baksi DP, Pal AK, Baksi D. Prosthetic replacement of elbow for intercondylar fractures (recent or ununited) of humerus in the elderly. *Int Orthop*. 2011;35:1171-1177. doi:10.1007/s00264-010-1122-5.
- [4] Throckmorton T, Zarkadas P, Sanchez-Sotelo J, Morrey B. Failure patterns after linked semiconstrained total elbow arthroplasty for posttraumatic arthritis. *J Bone Joint Surg Am*. 2010;92:1432-1441. doi:10.2106/JBJS.I.00145.
- [5] Cil A, Veillette CJH, Sanchez-Sotelo J, Morrey BF. Linked elbow replacement: a salvage procedure for distal humeral nonunion. *J Bone Joint Surg Am*. 2008;90:1939-1950. doi:10.2106/JBJS.G.00690.
- [6] Peden JP, Morrey BF. Total elbow replacement for the management of the ankylosed or fused elbow. *J Bone Joint Surg Br*. 2008;90:1198-1204. doi:10.1302/0301-620X.90B9.19967.
- [7] Sorbie C, Saunders G, Carson P, Hopman WM, Olney SJ, Sorbie J. Long-term effectiveness of Sorbie-QUESTOR elbow arthroplasty: single surgeon's series of 15 years. *Orthopedics*. 2011;34:e561-e569. doi:10.3928/01477447-20110714-08.
- [8] Morrey BF, Bryan RS. Infection after total elbow arthroplasty. *J Bone Joint Surg Am*. 1983;65:330-338.

