

**A report for
Universitätsklinikum Schleswig-Holstein/Campus Kiel
on shared decision making for pulpally involved teeth
(endodontic treatment vs. extraction followed by any
prosthetic care)**



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LIST OF ABBREVIATIONS

CCT	Controlled clinical trial
CDSR	Cochrane Database of Systematic Reviews
CI	Confidence interval
CPG	Clinical practice guideline
CRD	Centre for Reviews and Dissemination
DA	Decision aid
DARE	Database of Abstracts of Reviews of Effects
EMS	Endodontic microsurgery
FAQ	Frequently asked question
GIN	Guidelines International Network
GRADE	Grading of Recommendations, Assessment, Development and Evaluations
HRQoL	Health-related quality of life
HTA	Health Technology Assessment
ICU	Intensive care unit
KSR	Kleijnen Systematic Reviews
N	Sample size
NA	Not applicable
NHS	National Health Service (UK)
NICE	National Institute for Health and Care Excellence (UK)
NR	Not reported
OHIP	Oral health impact
OR	Odds ratio
PICOS	Participants, intervention, comparators, outcomes, and study design
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
QoL	Quality of life
RC	Retrospective cohort
RCT	Randomised controlled trial
RER	Root-end resection
RES	Resin-based endodontic surgery
RoCT	Root canal treatment
RR	Risk ratio
SDM	Shared decision making
SR	Systematic review
UK	United Kingdom
VAS	Visual analogue scale

1. PROJECT OBJECTIVE

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 the relevant treatment options.

The topic of this evidence report is pulpally involved teeth (endodontic treatment vs. extraction followed by any prosthetic care).

2. METHODS

2.1 INCLUSION CRITERIA

The research question underpinning the literature searches for this topic was developed in conjunction with clinical departments at Universitätsklinikum Schleswig-Holstein/Campus Kiel. The question was framed in terms of participants, intervention, comparators, outcomes, and study design (PICOS), see Table 1.

Table 1: Inclusion and exclusion criteria

	Included	Excluded
Population	Individuals with pulpally involved teeth, including: • a result of either caries or trauma • both first line and retreatment • any tooth or set of teeth	Non-pulpally involved teeth
Intervention	Endodontic treatment, including: • root tip resection (Apicoectomy) • root canal treatment • revision of root canal filling	Not endodontic treatment
Comparator	Extraction of tooth/teeth and fitting of: • no prosthesis • denture • bridge • implant	No extraction
Outcomes	• All-cause mortality • Pain: acute and chronic • Intervention related morbidity • Sensitivity to cold/heat • Peri-procedural complications: ○ Infection ○ Bleeding • Health-related quality of life (HRQoL) • Satisfaction with care/treatment • Function/mastication ability • Operative time/anaesthesia time • Visual appearance • Risk of failure • Risk of retreatment	Those not listed
Study design	Systematic reviews, health technology assessments and guidelines; primary research including RCTs, CCTs, cohort studies*	Literature reviews; expert opinions; letters
Effect modification / Subgroups	• a result of either caries or trauma • first line or retreatment	Not applicable
*to be considered if evidence from SRs/CPGs is scarce		

2.2 FREQUENTLY ASKED QUESTIONS

The following research questions were identified as frequently asked questions (FAQs):

1. What does treatment for pulpally involved teeth involve?
 - a. What is the procedure?
 - b. Length of procedure (operative time/anaesthesia time)
 - c. Length of stay
 - d. Anaesthesia choices
2. What are the long-term risks i.e. of failure/retreatment?
3. How will quality of life/satisfaction be affected?
 - a. What will be the effect on aesthetic appearance?
 - b. How will function/mastication be affected?
4. How much pain/sensitivity will be involved?
5. What are the short-term risks i.e. of peri-procedural complications (infection, pain, bleeding)?
6. What are the financial cost/resource implications to the patient?

2.3 LITERATURE SEARCHES

Literature searches were conducted to identify systematic reviews, health technology assessments (HTAs) and guidelines on pulpally involved teeth (endodontic treatment vs. extraction followed by any prosthetic care).

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 to 2015-2020. Searches were not limited by language or publication status.

Search sources

The following systematic review specific databases were searched from 2015 to present:

- Cochrane Database of Systematic Reviews (CDSR) (Wiley): issue 9, September 2020
- Health Technology Assessment (HTA) database (CRD): 2015 to 31 March 2018
- KSR Evidence (Internet) (<https://ksrevidence.com/>): 2015-2020
- Epistemonikos (Internet) (<https://www.epistemonikos.org/>): 2015-2019
- International HTA Database (INAHTA) (<https://database.inahta.org/>): up to 25 September 2020

The following guidelines resources were searched from 2015 to present:

- Guidelines International Network (GIN) (Internet) (<https://www.g-i-n.net/home>): up to 23 September 2020
- NICE Evidence (Internet) (www.evidence.nhs.uk/): 2015-2020
- NICE Guidance (Internet) (<https://www.nice.org.uk/guidance>): 2015-2020

- ECRI Guidelines Trust (Internet) (<https://guidelines.ecri.org/>): 2015-2020

The following relevant organisations were searched for guidelines from 2015 to present:

- European Society of Endodontology (<https://www.e-s-e.eu/index.html>): up to 1 October 2020
- British Endodontic Society (<https://britishendodonticsociety.org.uk/>): up to 1 October 2020
- American Association of Endodontists (<https://www.aae.org/>): up to 1 October 2020
- German Society of Endodontology and Traumatology (<https://www.dget.de/fuer-zahnaerzte/wissenschaftliche-mitteilungen>): up to 1 October 2020
- Scottish Dental Clinical Effectiveness Programme (<https://www.sdcep.org.uk/published-guidance/>): up to 1 October 2020
- American Dental Association (<https://www.ada.org/en>): up to 1 October 2020

2.4 TARGETED SEARCHES

To identify questions related to shared decision making and pulpally involved teeth, targeted searches were undertaken in the following databases from 2015 to present:

- EMBASE (Ovid): 1974 – 24 September 2020
- MEDLINE and Epub Ahead of Print, In-Process & Other Non-Indexed Citations and Daily (Ovid): 1946 – 24 September 2020
- Cochrane Central Register of Controlled Trials (CENTRAL) (Wiley): issue 9, September 2020

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.

2.5 METHODS OF STUDY SELECTION, QUALITY ASSESSMENT AND DATA EXTRACTION

Study selection

Two reviewers independently screened the title and abstract of each record identified by the searches and determined the potential relevance of each record. For potentially relevant records, the full paper was obtained, independently checked by two reviewers, and inclusion criteria applied. Any disagreements were resolved through discussion.

An evidence hierarchy was used to select the most appropriate study(ies) to populate the evidence tables. Where more than one study could provide evidence, the most relevant studies were selected using the following criteria: recency (most recent preferred), quality (highest quality preferred), representativeness (populations representative of the general target population preferred). Where there were gaps in the evidence (no systematic review or guideline available), as described before, relevant randomised controlled

trials (RCTs) would have been searched for and extracted, and where no RCTs would have been identified, observational studies would have been searched for and extracted.

Data extraction

For each study, data were extracted by one reviewer and checked by another. Any disagreements were resolved by consensus.

Meta-analysis

For three reviews presenting raw binary (n/N) data from each primary study where no meta-analysis per intervention had been conducted, we extracted those binary data to conduct our own de novo meta-analyses, estimating for each intervention the proportion of patients or teeth experiencing each outcome.

Specifically, we extracted and meta-analysed:

- 1) The percentage of radiological, clinical or global failures from Chercoles-Ruiz 2017¹ for: i) endodontic treatment, ii) apical surgery and iii) single tooth implants
- 2) The (binary) incidence of pain after root canal therapy from Sun 2018², using: i) manual tools, ii) reciprocating tools, iii) rotary tools and iv) any tools
- 3) The number of successes and number of complications from Cosyn 2019³ for: i) immediate implant placements, and ii) delayed implant placements
- 4) The number of complete implant losses and the number of postoperative infections from Chrcanovic 2014⁴ for: i) immediate implant placements, and ii) delayed implant placements, for a) all studies, and for complete implant losses only: b) controlled studies, c) full arch prostheses, d) mandible implants only, e) maxilla implants only, and f) single crowns

We used the metaprop command in Stata (version 14.2) to conduct random effects meta-analyses, with continuity corrections of 0.5 and using the Wilson score method for confidence intervals.

The pooled estimates are reported in the main body of the report and the individual study data for each meta-analysis are presented in Appendix 4.

3. RESULTS

3.1 LITERATURE SEARCH RESULTS AND INCLUSION ASSESSMENT

Searches were conducted in September 2020 to identify systematic reviews, health technology assessments or evidence-based guidelines. From the literature searches, after removal of duplicate records 1,772 titles and abstracts were screened by two reviewers. After screening, 69 records were selected for further assessment, from which 12 systematic reviews were selected as meeting the inclusion criteria. A summary of the study selection process according to modified PRISMA reporting guidelines⁵ is reported in Figure 1.

3.2 OVERVIEW OF THE EVIDENCE

Although two of the reviews, by Chercoles-Ruiz 2017,¹ and Torabinejad 2015,⁶ compared some form of endodontic treatment with some form of extraction with prosthetic implant, only Chercoles-Ruiz 2017,¹ retrieved any comparative primary studies. These three studies, by Doyle 2006,⁷ Vozza 2013⁸ and Hannahan 2008,⁹ compared some measure of treatment failure between root canal treatment (RoCT, referred to as endodontic treatment here) and extraction and prosthetic implant. These studies have therefore been reported separately, and all studies were of a low-quality design, as one was cross-sectional and two were retrospective cohorts. Leong 2020¹⁰ also included a single primary study, by Gatten 2011,¹¹ that compared any form of endodontic treatment with any form of extraction. However, the other studies in the review only assessed RoCT, and for all studies the only outcome was health-related quality of life (HRQoL). Therefore, each included review was, apart from these two exceptions, a source of only non-comparative data for at least one endodontic or extraction intervention.

Seven studies were sources of RoCT data, by Olivieri 2020,¹² Del Fabbro 2016,¹³ Manfredi 2016,¹⁴ Antunes 2018,¹⁵ Sun 2018,² Leong 2020¹⁰ and Chercoles-Ruiz 2017.¹ One of these studies, by Del Fabbro 2016,¹³ compared RoCT with root-end resection (apicectomy), meaning it was a source for both types of endodontic intervention. One study, by Chercoles-Ruiz 2017,¹ was a source of both types of endodontic intervention as well as implant. One study, by Kohli 2018,¹⁶ compared two types of root-end resection, resin-based endodontic surgery (RES) and endodontic microsurgery (EMS). One study, by Torabinejad 2015,⁶ compared studies examining root-end resection interventions with studies examining extraction plus implant, which meant that it was a source of both one type of endodontic and one type of extraction intervention. Therefore, in total, there were four sources of data for root-end resection. Two studies, by Cosyn 2019³ and Chrcanovic 2015,⁴ compared two different time points of inserting implants after extraction, i.e. immediate vs. delayed (healed). One study, by Torabinejad 2015¹⁷ compared implant to intentional replacement of a tooth. Therefore, there were five sources of implant data. There were no sources of data on extraction except followed by implant.

The risk of bias assessment revealed some variation between the reviews (see Appendix 3). However, all of the evidence can be regarded as being of low quality given the high risk of bias of the included primary studies.

Figure 1: Study selection process

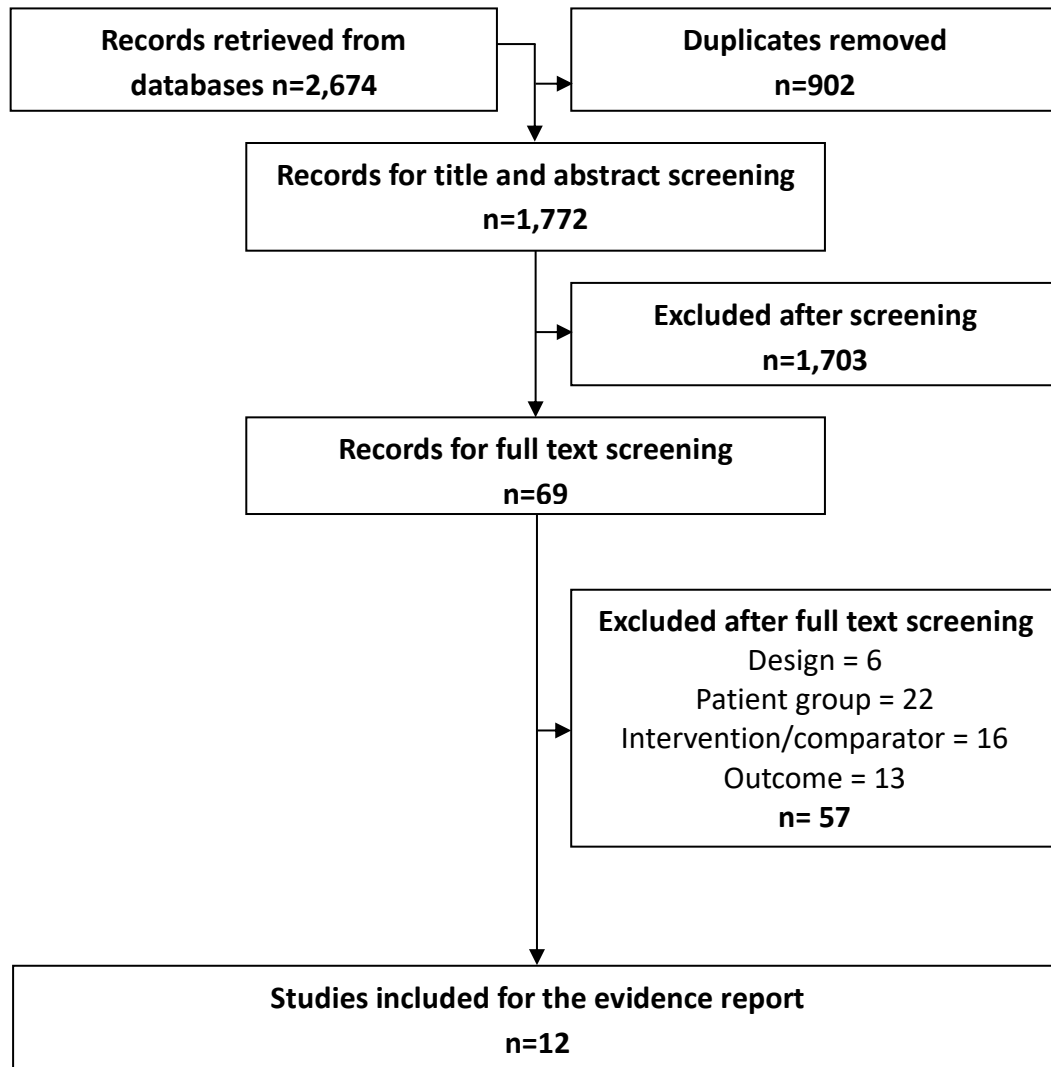


Table 2 summarises the sources of evidence used to answer the six FAQs. Note that no studies were found that reported cost.

Table 2: Evidence sources

Study/ year	Aetiology	Line	Teeth	Intervention type	Intervention			FAQ 1: treatment description	FAQ 2: survival/ failure	FAQ 3: HRQoL *	FAQ 3: Pain	FAQ 4: Complications	No. of studies in review	No. of comparative^ studies in review
					1	2	3							
Olivieri 2020 ¹²	trauma	1 st	posterior	Endodontic	RoCT	NA	NA	Yes	Yes	No	No	No	7	0
Cosyn 2019 ³	NR /unclear	1 st	mixed	Extraction	implant, delayed	implant, immediate		Yes	Yes	Yes	Yes	Yes	8	0
Kohli 2018 ¹⁶	NR /unclear	mixed	NR /unclear	Endodontic	RES	EMS		Yes	Yes	No	No	No	14	0
Torabinejad 2015 ⁶	NR /unclear	revision	NR /unclear	Endodontic vs. extraction	EMS	implant		Yes	Yes	Yes	Yes	Yes	50	0
Torabinejad 2015 ¹⁷	NR /unclear	NR/unclean	NR /unclear	Extraction	implant only	intentionally replanted		Yes	Yes	No	No	No	35	0
Del Fabbro 2016 ¹³	NR /unclear	revision	mixed	Endodontic	RoCT	RER		Yes	No	No	Yes	No	20	0
Manfredi 2016 ¹⁴	NR /unclear	1 st	mixed	Endodontic	RoCT, single visit	RoCT, multiple visits		Yes	Yes	No	Yes	Yes	25	0
Leong 2020 ¹⁰	NR /unclear	mixed	mixed	Endodontic vs. extraction	RoCT	implant (only 1 study vs. RoCT)		Yes	No	Yes	No	No	6	1
Antunes 2018 ¹⁵	NR /unclear	mixed	mixed	Endodontic	RoCT	NA	RoCT, reciprocal instruments	Yes	No	Yes	No	No	2	0
Sun 2018 ²	NR /unclear	1 st	mixed	Endodontic	RoCT, manual instruments	RoCT, rotary instruments		Yes	No	No	Yes	No	17	0

Study/ year	Aetiology	Line	Teeth	Intervention type	Intervention			FAQ 1: treatment description	FAQ 2: survival/ failure	FAQ 3: HRQoL *	FAQ 3: Pain	FAQ 4: Complications	No. of studies in review	No. of comparative^ studies in review
					1	2	3							
Chrcanovic 2015 ⁴	NR /unclear	NR/unclear	NR /unclear	Extraction	Implant, delayed	Implant, immediate	NA	Yes	Yes	No	No	Yes	73	0
Chercoles-Ruiz 2017 ¹	NR /unclear	NR/unclear	NR /unclear	Endodontic vs. extraction	RoCT	RER	implant	Yes	Yes	No	No	No	45	3
* Includes satisfaction and aesthetics; ^ Comparing endodontic to extraction intervention EMS = endodontic microsurgery, NA = not applicable, NR = not reported, RER = root-end resection (apicectomy), RES = resin-based endodontic surgery														

3.3 FAQ1: WHAT DOES IT INVOLVE?

This section has been written by reference to the two systematic reviews that compare endodontic to extraction interventions, by Chercoles-Ruiz 2017¹ and Torabinejad 2015.⁶

Table 3: FAQ 1 - Description of options

Endodontic treatment
Conventional endodontic retreatment is often referred to as RoCT. This is regarded as standard of care of a pulpally involved tooth to attempt to preserve that tooth. Although in some cases this decision may be controversial, it should be based on the remnant tooth structure, patient preferences, and cost effectiveness. On failure of RoCT, as an alternative to extraction, RoCT revision could be performed or endodontic surgery, otherwise known as root-end resection or apicectomy, as compared in Del Fabbro 2016.¹³ The latest technique is referred to as endodontic microsurgery, which involves an operating microscope to better identify canals, fractures, and isthmuses, as considered in Kohli 2018¹⁶. There are also various characteristics of RoCT, two of which have been examined in the included reviews, single vs. multiple visits by Manfredi 2016¹⁴ and type of instruments, either manual, rotary or reciprocating, as reviewed by Sun 2018.² In general, local anaesthetic is used to block the pain of RoCTs.¹⁸ The treatment consists of drilling a hole in the top of the tooth, removing the pulp and then cleaning and disinfecting the inside of the tooth, then filling and sealing the tooth. Different tools are used in each stage of the RoCT. Depending on the number of visits, the filling may be permanent or temporary, necessitating a second visit to remove the temporary filling and place a permanent filling. RoCTs may need to be repeated if the tooth cracks or more decay develops. Painkillers may be given after the RoCT to reduce pain (which should reduce by two weeks post-RoCT).
Extraction
Although there might generally be the aim to preserve the tooth, extraction and dental implant placement is a widely accepted treatment option, although there are many factors that can affect the result such as implant position, bone quality and smoking habits. Local anaesthetic is routinely used to block the pain of extraction, though sedation and general anaesthetic are also given if required, though if a general anaesthetic is given the extraction must be performed in a hospital.¹⁹ The tooth is removed by widening the socket the tooth sits in, then pulling the tooth free. Dental implants can be inserted immediately after extraction, given the belief that bone loss increases with time, thus compromising placement, but delayed insertion, i.e. until the socket has healed (usually after 3-6 months), is also an option, as described in the systematic reviews by Cosyn 2019³ and Chrcanovic 2015.⁴ If an implant isn't placed immediately after the extraction, then a stitch may be placed in the socket to help it close and heal. Painkillers and antibacterial mouthwash may be given after any extraction to reduce pain (which should reduce by 10 days post-extraction) and the chance of infection.

3.4 FAQ2: WHAT ARE THE LONG-TERM RISKS I.E. OF FAILURE/RETREATMENT?

Table 4: FAQ 2 - Intervention failure

Line	Intervention	Study	Failure/success definition	Follow-up time	Failure risk (95% CI)*	No. of studies	Certainty – quality of evidence)	Assessment for use in DA
1 st	RoCT any	Olivieri 2020 ¹²	Presence of a tooth and extraction not planned at follow-up *	1 year	12.00% (6.00%,19.00%)	7	All low quality given non-comparative and multiple or unclear definitions of population, outcome and follow-up time.	- No outcomes for implant. Unclear difference between RoCT and RER.
			Radiographically and clinically*	1 year	18.00% (14.00%,22.00%)	3		
	RoCT, multiple visits	Manfredi 2016 ¹⁴	Radiological	NR	14.60% (NA)	11		
			Tooth extraction due to endodontic problems		1.90% (NA)	1		
	RoCT, single visit		Radiological		13.20% (9.90%,17.60%)	11		
			Tooth extraction due to endodontic problems		0.90% (0.10%,8.80%)	1		
	RER, EMS	Kohli 2018 ¹⁶	Radiographically (complete or incomplete healing (scar tissue formation)) and clinically (absence of pain, swelling, percussion sensitivity, or sinus tracts)*	12-96 months	5.58% (4.10%,7.05%)	11		
	RER, RES	Kohli 2018 ¹⁶	Radiographically (complete or incomplete healing (scar tissue formation)) and clinically (absence of pain, swelling,	12-119 months	17.80% (15.24%,20.35%)	3		

Line	Intervention	Study	Failure/success definition	Follow-up time	Failure risk (95% CI)*	No. of studies	Certainty – quality of evidence)	Assessment for use in DA	
			percussion sensitivity, or sinus tracts)*						
Revision	RoCT, any	Del Fabbro 2016 ¹³	Healing of periapical pathology evaluated by assessment of clinical signs and symptoms (absence of pain, suppuration, swelling) and through two-dimensional or three-dimensional radiological examination*	1 year	27.42% (NA)	2		↔	All values for implant much better than those for either RoCT or RER.
	RER, any				16.50% (2.00%,29.60%)	2			
	RER, EMS	Torabinejad 2015 ⁶	Unclear (Molven criteria most often used) complete, incomplete, and uncertain healing with no clinical symptoms	2-4 years	6.00% (3.00%,9.00%)	4			
				4-6 years	12.00% (8.00%,16.00%)	2			
			Unclear (Molven criteria most often used) complete, incomplete, and uncertain healing with no clinical symptoms*	2-4 years	10.00% (6.00%,14.00%)	4			
				4-6 years	16.00% (4.00%,33.00%)	2			
	Implant, any		Unclear (criteria of Albrektsson et al, Albrektsson and Isidor, and Buser et al were the most commonly used, but survival and success was used interchangeable)*	2-4 years	2.00% (0.00%,5.00%)	5			
				4-6 yeas	2.00% (1.00%,3.00%)	12			
				6+ years	3.00% (0.00%,9.00%)	2			

Line	Intervention	Study	Failure/success definition	Follow-up time	Failure risk (95% CI)*	No. of studies	Certainty – quality of evidence)	Assessment for use in DA		
			Unclear (Misch criteria most often used in studies, but survival and success were used interchangeable)	2-4 years	4.00% (2.00%,7.00%)	13				
				4-6 years	3.00% (1.00%,4.00%)	7				
				6+ years	2.00% (1.00%,5.00%)	7				
		Torabinejad 2015 ¹⁷	Misch criterial (implants still in function but not necessarily with ideal conditions)	NR	3.00% (2.00%,4.00%)	27				
NR/ unclear	RoCT, any	Chercoles-Ruiz 2017 ¹	Radiological/Clinical/Global failure	2 to 10 years	9.98% (8.57%,11.39%)^	17			- Non-comparative values for implant much better than those for either RoCT or RER. However, comparative study values seem quite close.	
	RER, any	Chercoles-Ruiz 2017 ¹	Radiological/Clinical/Global failure	4 months to 10 years	10.78% (7.78%,13.77%)^	20				
	Implant, any			1 to 12 years	4.78% (3.05%,6.51%)^	13				
	Implant, delayed	Chrcanovic 2015 ⁴	Complete loss of the implant	18 days to 12 years	2.27% (1.77%,2.76%)^	73				
	Implant, delayed (≥ 3 months)	Cosyn 2019 ³	Implant survival*	1 to 8 years	0.36% (0%,1.74%)^	8				
	Implant, immediate	Chrcanovic 2015 ⁴	Complete loss of the implant	18 days to 12 years	3.32% (2.62%,4.03%)^	73				
	Implant, immediate (<24 hours)	Cosyn 2019 ³	Implant survival*	1 to 8 years	3.14% (0.43%,5.85%)^	8				
	Results of three comparative studies reported in Chercoles-Ruiz 2017 ¹									
	RoCT, any	Doyle 2006 ⁷	Radiological	2 years	6.10% (2.7%,9.5%)	1 CS				
		Hannahan 2008 ⁹	Radiological	22 months	0.70% (0.00%,2.1%)	1 RC				

Line	Intervention	Study	Failure/success definition	Follow-up time	Failure risk (95% CI)*	No. of studies	Certainty – quality of evidence)	Assessment for use in DA
	Implant, any	Vozza 2013 ⁸	NR	8 years	16.70% (5.4%,28.0%)	1 RC		
		Doyle 2006 ⁷	NR	2 years	6.10% (2.7%,9.5%)	1 CS		
		Hannahan 2008 ⁹	NR	36 months	1.60% (0.00%,3.8%)	1 RC		
		Vozza 2013 ⁸	Clinical	8 years	19.20% (7.9%,30.5%)	1 RC		

*Outcome reported as either success or survival and thus failure risk calculated difference from 100%.

^Estimated using de novo meta-analysis.

'NA' is used instead of the 95% CI in order to indicate that in two reviews, which were all Cochrane ones, the estimate for the comparator (RoCT, multiple visits in Manfredi 2016¹⁴ and RoCT, any in Del Fabbro 2016¹³) was stated to be assumed and no 95% CI was reported. On checking, it emerged that it had been calculated using a naïve method of meta-analysis (sum across all trials of patients with event/sum across all trials of sample size).

CI = confidence interval; CS = cross-sectional, DA = decision aid; EMS = endodontic microsurgery, FAQ = frequently asked question; NA = not applicable, NR = not reported, RER = root-end resection (apicectomy), RC = retrospective cohort, RES = resin-based endodontic surgery

3.5 FAQ 3: HOW IS HEALTH-RELATED QUALITY OF LIFE (HRQoL), INCLUDING AESTHETICS AND FUNCTION AFFECTED?

Three reviews provided only a qualitative summary of the effect of interventions on HRQoL or satisfaction, which are summarised in Table 5.

Table 5: FAQ 3 - Health-related quality of life

Line	Intervention	Study ID	Outcome	Follow-up time	Summary	No. of studies	Certainty – quality of evidence)	Assessment for use in DA
Mixed	RoCT, any	Antunes 2018 ¹⁵	HRQoL, OHIP-14 and OHIP-17	NR	The two studies used different versions of the oral health impact (OHIP) scale, and did not have sufficient data to combine the estimates. However, in both studies, oral HRQoL was improved by endodontic treatment: in the first study by 6.2 points (OHIP-14) after 1 month, and in the second study by 4.03 points (OHIP-17) after 2 weeks. Additionally, in the first study, all 7 domains of the OHIP-14 were statistically significantly reduced (HRQoL improved).	2	All low quality given non-comparative and multiple or unclear definitions of population, outcome, and follow-up time.	- The evidence is insufficient to infer the size of any difference between endodontic and extraction interventions of any kind.
		Leong 2020 ¹⁰	HRQoL, tools: OHIP-17 (2 studies), OHIP-14 (3 studies), OIDP (1 study)	NR	Four out of six studies concluded that non-surgical RoCT improved HRQoL. Two studies investigated the impact of persistent post-endodontic pain and reported a deleterious effect on HRQoL, but with minimal impact on daily activities. Only 1 paper compared the endodontic treatment with a	6		

Line	Intervention	Study ID	Outcome	Follow-up time	Summary	No. of studies	Certainty – quality of evidence)	Assessment for use in DA
					dental implant: the OHIP scores were comparable between both treatments with a high level of satisfaction with both interventions.			
	implant, delayed (≥3 months)	Cosyn 2019 ³	Patient satisfaction VAS	1 year	Both interventions were reported to have VAS of >85 (out of 100). >85 (NA)	2		
	implant, immediate (<24 hours)	Cosyn 2019 ³	Patient satisfaction VAS			2		
Revision	Implant, any	Torabinejad 2015 ⁶	satisfaction, unclear definition	NR	"high levels of satisfaction; some differences between early and late satisfaction ratings, but overall satisfaction with mastication, esthetics, and final restoration was reported"	1		
					"high satisfaction with postoperative results and instructions but less satisfaction with pain"	1		
					"high satisfaction with esthetics and function but less satisfaction with cleansability"	1		
					"very high satisfaction after restoration, but this decreased over time"	1		

DA = decision aid; FAQ = frequently asked question; HRQoL = health-related quality of life; NA = not applicable; NR = not reported; OHIP = oral health impact; RoCT = root canal treatment; VAS = visual analogue scale

3.6 FAQ 4: HOW IS PAIN AFFECTED?

Two studies reported pain on a visual analogue scale (VAS) and three as a binary outcome (risk of pain), see Tables 6 and 7.

Table 6: FAQ 4 - VAS pain

line	intervention	Study ID	Outcome details	Follow-up time	Mean (95% CI)	No. of studies	Certainty – quality of evidence)	Assessment for use in DA
1 st	RoCT, manual tools	Sun 2018 ²	VAS pain	6-8 hours	4.43 (3.13 to 5.73)	2	All low quality given non-comparative and multiple or unclear definitions of population, and follow-up time.	- The evidence is insufficient to infer the size of any difference between endodontic and extraction interventions of any kind.
				12 hours	3.80 (3.17 to 4.43)	2		
				24 hours	2.69 (2.13 to 3.25)	2		
	RoCT, rotary tools			6-8 hours	2.25 (-0.20 to 4.70)	2		
				12 hours	1.04 (-0.27 to 2.34)	2		
				24 hours	0.83 (0.46 to 1.20)	2		
Mixed	Implant, delayed (≥ 3 months)	Cosyn 2019 ³		1 year	0.80 (0.58 to 1.02)	1		
	Implant, immediate (<24 hours)				1.30 (0.90 to 1.70)	1		
CI = confidence interval; DA = decision aid; FAQ = frequently asked question; RoCT = root canal treatment								

Table 7: FAQ 4 - risk of pain

Line	Intervention	Study ID	Outcome	Follow-up time	Risk (95% CI)	No. of studies	Certainty – quality of evidence)	Assessment for use in DA
1 st	RoCT, any	Sun 2018 ²	Risk of pain	6 hours to 1 day	43.67% (30.07% to 57.27%)^	23	All low quality given non-comparative and multiple or unclear definitions of population, and follow-up time. Also, there is no evidence for any extraction intervention.	- The evidence is insufficient to infer the size of any difference between endodontic and extraction interventions of any kind.
	RoCT, manual tools				46.46% (13.73% to 79.19%)^	6		
	RoCT, rotary tools				32.43% (21.38% to 43.48%)^	11		
	RoCT, reciprocating tools				58.74% (20.05% to 97.43%)^	6		
	RoCT, multiple visits	Manfredi 2016 ¹⁴		72 hours post-obturation	62.10% (NA)	9		
	RoCT, single visit			1 week	89.10% (NA)	8		
				72 hours post-obturation	62.50% (55.70% to 68.20%)	9		
				1 week	83.60% (75.10% to 89.20%)	8		
Revision	RER, any	Del Fabbro 2016 ¹³	day 1	6.80% (0% to 42.80%)	1			
RoCT, any	72.10% (NA)			1				
^Estimated using de novo meta-analysis CI = confidence interval; DA = decision aid; FAQ = frequently asked question; NA = not applicable; RER = root-end resection; RoCT = root canal treatment								

3.7 FAQ 5: HOW ARE COMPLICATIONS AFFECTED?

Table 8: FAQ 5 - Complications

Line	Intervention	Study ID	Failure definition	Follow-up time	Risk (95% CI)	No. of studies	Certainty – quality of evidence)	Assessment for use in DA
1 st	RoCT, multiple visits	Manfredi 2016 ¹⁴	any complication	NR	28.60% (NA)	10	All low quality given non-comparative and multiple or unclear definitions of population, and follow-up time. Also, there is no evidence for any extraction intervention	- The evidence is insufficient to infer the size of any difference between endodontic and extraction interventions of any kind.
			sinus track or fistula formation		1.20% (NA)	2		
			swelling or flare-up		8.10% (NA)	4		
	RoCT, single visit		any complication		26.30% (22.00%, 31.70%)	10		
			sinus track or fistula formation		1.20% (0.20%, 7.80%)	2		
			swelling or flare-up		11.00% (5.30%, 22.60%)	4		
NR/ unclear	Implant, delayed (≥ 3 months)	Cosyn 2019 ³	Biological complications	1 to 8 years	0% in one;13% in other, inc. fistula, bone loss, pain	2		
			Technical complications		5.83% (0%, 14.32%)^	4		
	Implant, immediate (<24 hours)		Biological complications		0% in both studies	2		
			Technical complications		8.16% (0%, 18.14%)^	4		
^Estimated using de novo meta-analysis CI = confidence interval; DA = decision aid; FAQ = frequently asked question; NA = not applicable; NR = not reported; RoCT = root canal treatment								

3.8 FAQ 6: WHAT ARE THE FINANCIAL COST/RESOURCE IMPLICATIONS TO THE PATIENT?

No evidence available.

4. DISCUSSION

4.1 SUMMARY OF FINDINGS

After screening 1,772 references, 12 studies were included, which were all systematic reviews, covering a range of endodontic interventions, including RoCT and RER and one main type of extraction intervention, implant. Two of these reviews were designed to compare at least one endodontic intervention to implant and one of these included three non-RCT primary studies that compared an endodontic intervention to implant. One other review, ostensibly about endodontic treatment also included this kind of comparative study. All evidence was of low certainty in that there was no RCT or even prospective cohort study comparing endodontic intervention to implant, but also given multiple or unclear definitions of population, outcome, and follow-up time. The value of the evidence on outcomes for the DA, for each of the FAQs, can be summarised as follows:

2. What are the long-term risks i.e. of failure/retreatment?
 - a. First-line: no evidence
 - b. Revision: all non-comparative values for implant much better than those for either RoCT or RER. However, when the line of therapy is unclear, those from the three comparative studies included in the review by Chercoles-Ruiz 2017¹ suggest that there is little difference between implant and RoCT.

However, the evidence is insufficient to infer the size of any difference between endodontic and extraction interventions of any kind for all of the following FAQs:

3. How will quality of life/satisfaction be affected?
4. How much pain/sensitivity will be involved?
5. What are the short-term risks i.e. of peri-procedural complications (infection, pain, bleeding)?

There was no evidence for the following FAQ:

6. What are the financial cost/resource implications to the patient?

4.2 STRENGTHS, LIMITATIONS AND UNCERTAINTIES

This report was developed based on evidence from systematic reviews. Strengths of this report include thorough literature searches and the inclusion of the most recent evidence. The report also covered a wide range of outcomes of interest.

Although 12 systematic reviews were included, and two of them compared some form of endodontic to some form of extraction intervention, only four comparative primary studies were retrieved and none could be regarded as of low risk of bias. Also, although studies of the main types of endodontic intervention, RoCT and RER (apicectomy), were included, only studies of one main type of extraction intervention, implant, were retrieved, there being no studies of extraction without replacement. There was also a complete absence of evidence on the relative cost to the patient of the interventions and by far most of the evidence was

on the success/failure or some measure of survival of the tooth or prosthesis. However, despite these evidence gaps, there were several reviews and between them a considerable number of included primary studies, albeit largely of low quality for addressing the comparison of endodontic and extraction interventions. It is important to bear in mind that a lack of credible evidence should in no way diminish the importance of these issues in the decision-making process. Where evidence is not available, it will be important to monitor emerging primary studies and consensus expert opinion.

Methodological limitations of this review are that the searches were restricted to publications dated from 2015, that the selection of the records was mainly based on other evidence syntheses and not primary studies, and that little information on the risk of bias assessments of the primary studies, other than the basic design, none of which were RCTs, was reported. However, as this review included a search that was likely to find all systematic reviews published in the last five years, findings published by relevant primary studies and earlier reviews may be assumed to have been largely collected.

4.3 CONCLUSION

In general terms, the evidence is insufficient to suggest that any form of endodontic intervention is preferable to any extraction intervention or vice versa at any line of therapy or for any aetiology of pulpal involvement. The implication is that the choice of intervention would probably be made according to clinical and patient preferences.

5. REFERENCES

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APPENDIX 1: SEARCH STRATEGIES

Database	Dates	Results
CDSR	Iss 9, Sept 2020	52
HTA	Up to 31 Mar 2018	1
NICE Evidence	Up to 2020/09/23	156
NICE Guidance	Up to 2020/09/23	0
KSR Evidence	Up to 2020/09/25	1,148
Epistemonikos	Up to 2020/09/25	1,045
GIN	Up to 2020/09/23	5
ECRI	Up to 2020/09/25	5
INAHTA	Up to 2020/09/25	5
EMBASE	1974 – 2020/09/24	72
MEDLINE	1946 – 2020/09/24	145
CENTRAL	Iss 9, Sept 2020	27
European Society of Endotontology	Up to 1.10.20	3
British Endodontic Society	Up to 1.10.20	1
American Association of Endodontists	Up to 1.10.20	6
German Society of Endotontology and Traumatology	Up to 1.10.20	2
Scottish Dental Clinical Effectiveness Programme	Up to 1.10.20	0
American Dental Association	Up to 1.10.20	1
Total		2,674
Total after deduplication		1,772

CDSR (Wiley): up to issue 9, September 2020

Searched: 25.9.20

- #1 MeSH descriptor: [Dental Pulp Diseases] explode all trees 806
- #2 MeSH descriptor: [Dental Pulp Cavity] explode all trees 597
- #3 MeSH descriptor: [Pulpitis] explode all trees 318
- #4 MeSH descriptor: [Tooth Injuries] explode all trees 250
- #5 ((pulp* NEAR/4 (disease* or cavit* or inflam* or necrosis)) or ((trauma* or avulsed or knocked or dislodg* or sublux* or injur* or displac* or luxat*) NEAR/4 (teeth or tooth or incisor* or molar* or pre-molar* or premolar* or canine*)) or "irreversible pulpitis" or "pulpally involve*" or "extensive decay*" or "necrotised infection*" or "necrotized infection*" or "apical periodontitis" or "periapical periodontitis" or "periradicular periodontitis"):ti,ab,kw 2309
- #6 #1 or #2 or #3 or #4 or #5 2657
- #7 MeSH descriptor: [Endodontics] explode all trees 1395
- #8 MeSH descriptor: [Tooth Replantation] explode all trees 17
- #9 MeSH descriptor: [Dental Implants, Single-Tooth] explode all trees 314
- #10 MeSH descriptor: [Dental Implantation] explode all trees 1222
- #11 MeSH descriptor: [Denture, Partial] explode all trees 350
- #12 MeSH descriptor: [Dentures] explode all trees 980
- #13 MeSH descriptor: [Dental Prosthesis] explode all trees 4267

#14 (((tooth or teeth or incisor* or dental or molar* or pre-molar* or premolar* or canine*) NEAR/4 (implant* or replant* or bridge* or prosthesis*) or denture*):ti,ab,kw
5100

#15 #7 #8 or #9 or #10 or #11 or #12 or #13 or #14 6911

#16 #6 and #15 453

#17 MeSH descriptor: [Root Canal Therapy] explode all trees 1082

#18 MeSH descriptor: [Pulpectomy] explode all trees 81

#19 MeSH descriptor: [Pulpotomy] explode all trees 159

#20 MeSH descriptor: [Apicoectomy] explode all trees 83

#21 MeSH descriptor: [Tooth Extraction] explode all trees 1748

#22 ("root canal*" or pulpectom* or pulpotom* or apicoectom* or (root NEAR/2 fill*) or (root NEAR/2 surg*) or (pulp* NEAR/2 (therap* or treat*))) :ti,ab,kw 3267

#23 (tooth or teeth or incisor* or dental or molar* or pre-molar* or premolar* or canine*) NEAR/4 (extract* or remov* or pull or "tak* out"):ti,ab,kw 6236

#24 #17 or #18 or #19 or #20 or #21 or #22 or #23 8921

#25 #16 or #24 with Cochrane Library publication date Between Jan 2015 and Dec 2020
4532

CDSR = 52

Cochrane Protocols = 2

Trials = 4474

Clinical Answers = 4

HTA Database (<https://www.crd.york.ac.uk/CRDWeb/>): up to 2018/03

Searched: 25.9.20

1	MeSH DESCRIPTOR Dental Pulp Diseases EXPLODE ALL TREES	28
2	MeSH DESCRIPTOR Dental Pulp Cavity EXPLODE ALL TREES	9
3	MeSH DESCRIPTOR Pulpitis EXPLODE ALL TREES	8
4	MeSH DESCRIPTOR Tooth Injuries EXPLODE ALL TREES	10
5	(pulp*) AND (disease* or cavit* or inflam* or necrosis)	49
6	("irreversible pulpitis") OR ("pulpally involve*") OR ("extensive decay*")	9
7	("necrotised infection*") OR ("necrotized infection*")	0
8	((trauma* or avulsed or knocked or dislodg* or sublux* or injur* or displac* or luxat*)) OR ((teeth or tooth or incisor* or molar or pre-molar* or premolar* or canine*))	5386
9	(apical or periapical or periradicular) AND (periodontitis)	8
10	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9	5411
11	MeSH DESCRIPTOR Endodontics EXPLODE ALL TREES	52
12	MeSH DESCRIPTOR Tooth Replantation EXPLODE ALL TREES	3
13	MeSH DESCRIPTOR Dental Implants, Single-Tooth EXPLODE ALL TREES	31
14	MeSH DESCRIPTOR Dental Implantation EXPLODE ALL TREES	125
15	MeSH DESCRIPTOR Denture, Partial EXPLODE ALL TREES	36
16	MeSH DESCRIPTOR Dentures EXPLODE ALL TREES	65
17	(tooth or teeth or incisor* or dental or molar* or pre-molar* or premolar* or canine*) AND (implant* or replant* or bridge* or prosth*)	354
18	(denture*)	88

19	#11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18	418
20	#10 AND #19	183
21	MeSH DESCRIPTOR Root Canal Therapy EXPLODE ALL TREES	36
22	MeSH DESCRIPTOR Pulpectomy EXPLODE ALL TREES	4
23	MeSH DESCRIPTOR Pulpotomy EXPLODE ALL TREES	6
24	MeSH DESCRIPTOR Apicoectomy EXPLODE ALL TREES	8
25	MeSH DESCRIPTOR Tooth Extraction EXPLODE ALL TREES	56
26	("root canal*" or pulpectom* or apicoectom* or pulpotom*)	72
27	("root end fill*") OR ("root end surg*")	2
28	("pulp* therap*") OR ("pulp* treat*")	6
29	(tooth or teeth or incisor* or dental or molar* or pre-molar* or premolar* or canine*) AND (extract* or remov* or pull or "tak* out")	560
30	#21 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27 OR #28 OR #29	597
31	#20 OR #30	647
32	(#31) IN HTA FROM 2015 TO 2020	1

NHS Evidence (www.evidence.nhs): up to 23 September 2020

Searched: 23.9.20

Search terms – filtered guidance/systematic reviews, 2015-2020	Hits
"pulp disease"	1
"pulp cavit"	0
"irreversible pulpitis"	29
"pulp necrosis"	12
"tooth injur"	0
"tooth trauma"	2
"extensive decay"	2
"root canal"	116
"dental extract"	0
"tooth extract"	0
"teeth extract"	0
"teeth remov"	0
"tooth remov"	0
"extraction of teeth"	4
"removal of teeth"	4
"removal of tooth"	1
"extraction of tooth"	0
Total	172
Total after de-duplication	156

NICE (www.nice.org.uk): up to 23 September 2020

Searched: 23.9.20

Search terms	Hits
Endodontics	0
Pulp disease	0
Pulpitis	0
"pulpectomy"	0
"dental extraction"	0
"tooth extraction"	1
Total filtered to Guidelines, 2015-2020	0

KSR Evidence (www.ksrevidence.com): up to 25.9.20

Searched: 25.9.20

- 1 pulp* and (disease* or cavit* or inflam* or necrosis) in All text 121 results
- 2 (trauma* or avulsed or knocked or dislodg* or sublux* or injur* or displac* or luxat*) and (teeth or tooth or incisor* or molar* or "pre-molar*" or premolar* or canine*) in All text 168 results
- 3 "irreversible pulpitis" or "pulpally involve*" or "extensive decay*" or "necrotised infection*" or "necrotized infection*" or "apical periodontitis" or "periapical periodontitis" or "periradicular periodontitis" in All text 87 results
- 4 #1 or #2 or #3 in All text 320 results
- 5 (tooth or teeth or incisor* or molar* or "pre-molar*" or premolar* or canine*) and (implant* or replant* or bridge* or prosth*) in All text 359 results
- 6 denture* or endodontic* in All text 431 results
- 7 #5 or #6 in All text 721 results
- 8 #4 and #7 in All text 112 results
- 9 "root canal*" or pulpectom* or pulpotom* or apicoectom* or "root end fill*" or "root end surg*" or "pulp* therap*" or "pulp* treat*" in All text 256 results
- 10 (tooth or teeth or incisor* or molar* or "pre-molar*" or premolar* or canine*) and (extract* or pull or remov* or "tak* out") in All text 975 results
- 11 #9 or #10 in All text 1138 results
- 12 #8 or #11 in All text Date published: 2015 - 2020 1148 results

Sorted by risk of bias

Search run Fri Sep 25 2020

Epistemonikos (<https://www.epistemonikos.org/>): up to 25.9.20

Searched: 25.9.20

(title:((title:((pulp*) AND (disease* OR cavit* OR inflam* OR necrosis)) OR abstract:((pulp*) AND (disease* OR cavit* OR inflam* OR necrosis))) OR (title:((trauma* OR avulsed OR knocked OR dislodg* OR sublux* OR injur* OR displac* OR luxat*) AND (teeth OR tooth OR incisor* OR molar* OR pre-molar* OR premolar* OR canine*)) OR abstract:((trauma* OR avulsed OR knocked OR dislodg* OR sublux* OR injur* OR displac* OR luxat*) AND (teeth OR tooth OR incisor* OR molar* OR pre-molar* OR premolar* OR canine*)) OR (title:("irreversible pulpitis" OR "pulpally involve*" OR "extensive decay*" OR "necrotised infection*" OR "necrotized infection*" OR "apical periodontitis" OR "periapical periodontitis" OR "periradicular periodontitis") OR abstract:("irreversible pulpitis" OR "pulpally involve*" OR "extensive decay*" OR "necrotised infection*" OR "necrotized infection*" OR "apical periodontitis" OR "periapical periodontitis" OR "periradicular periodontitis")) AND (title:(((tooth OR teeth OR incisor*

OR dental OR molar* OR pre-molar* OR premolar* OR canine*) AND (implant* OR replant* OR bridge* OR prosth*) OR abstract:(((tooth OR teeth OR incisor* OR dental OR molar* OR pre-molar* OR premolar* OR canine*) AND (implant* OR replant* OR bridge* OR prosth*))) OR (title:(denture* OR endodontic*) OR abstract:(denture* OR endodontic*)) OR abstract:(title:(pulp*) AND (disease* OR cavit* OR inflam* OR necrosis)) OR abstract:(pulp*) AND (disease* OR cavit* OR inflam* OR necrosis)) OR (title:(trauma* OR avulsed OR knocked OR dislodg* OR sublux* OR injur* OR displac* OR luxat*) AND (teeth OR tooth OR incisor* OR molar* OR pre-molar* OR premolar* OR canine*)) OR abstract:(trauma* OR avulsed OR knocked OR dislodg* OR sublux* OR injur* OR displac* OR luxat*) AND (teeth OR tooth OR incisor* OR molar* OR pre-molar* OR premolar* OR canine*)) OR (title:(irreversible pulpitis" OR "pulpally involve*" OR "extensive decay*" OR "necrotised infection*" OR "necrotized infection*" OR "apical periodontitis" OR "periapical periodontitis" OR "periradicular periodontitis") OR abstract:(irreversible pulpitis" OR "pulpally involve*" OR "extensive decay*" OR "necrotised infection*" OR "necrotized infection*" OR "apical periodontitis" OR "periapical periodontitis" OR "periradicular periodontitis")) AND (title:(tooth OR teeth OR incisor* OR dental OR molar* OR pre-molar* OR premolar* OR canine*) AND (implant* OR replant* OR bridge* OR prosth*)) OR abstract:(((tooth OR teeth OR incisor* OR dental OR molar* OR pre-molar* OR premolar* OR canine*) AND (implant* OR replant* OR bridge* OR prosth*)) OR (title:(denture* OR endodontic*) OR abstract:(denture* OR endodontic*))) OR (title:(root canal*" OR pulpectom* OR pulpotom* OR apicoectom* OR "root end surg*" OR "root end fill*")) OR abstract:(root canal*" OR pulpectom* OR pulpotom* OR apicoectom* OR "root end surg*" OR "root end fill*")) OR (title:(tooth OR teeth OR incisor* OR dental OR molar* OR pre-molar* OR premolar* OR canine*) AND (extract* OR "pull out" OR remov* OR "tak* out")) OR abstract:(tooth OR teeth OR incisor* OR dental OR molar* OR pre-molar* OR premolar* OR canine*) AND (extract* OR "pull out" OR remov* OR "tak* out"))

Filtered 2015-2020, Systematic reviews

1045 results

Guidelines International Network (G-I-N) (<https://g-i-n.net/>): up to 23.9.20

Searched: 23.9.20

Search term	Hits
Dental pulp diseases [MeSH]	0
Dental pulp cavity [MeSH]	0
Pulpitis [MeSH]	0
Tooth Injuries [MeSH]	2
Pulp disease*	0
Pulp inflam*	0
Pulp necrosis	0
(teeth) AND (trauma*)	1
(avulsed) AND (teeth)	1
(knocked) AND (teeth)	0
(dislodg*) AND (teeth)	0
(sublux*) AND (teeth)	0
(injur*) AND (teeth)	0
(displac*) AND (teeth)	0
(luxat*) AND (teeth)	0
(tooth) AND (trauma*)	1
(avulsed) AND (tooth)	0
(knocked) AND (tooth)	0

(dislodg*) AND (tooth)	0
(sublux*) AND (tooth)	0
(injur*) AND (tooth)	2
(displac*) AND (tooth)	1
(luxat*) AND (tooth)	0
Irreversible pulpitis	0
Pulpally involve*	0
Endodontics [MeSH]	1
Endodontic*	1
Root Canal Therapy [MeSH]	0
Root canal*	0
Pulpectomy [MeSH]	0
Pulpotomy [MeSH]	0
Tooth extraction [MeSH]	2
Pulpectom*	0
Pulpotom*	0
Tooth extract*	2
Teeth extract*	1
Dental extract*	1
Total	16
Total after de-duplication	7
Filtered 2015-2020	5

ECRI Guidelines Trust (<https://guidelines.ecri.org/>): up to 25.9.20

Searched: 25.9.20

'endodontic* OR "tooth extract*" OR "dental extract*" OR "root canal*" OR pulpectom* OR pulpotomy* OR apicoetom*'

5 results

International HTA Database (INAHTA) (<https://database.inahta.org/>): up to 25.9.20

Searched: 25.9.20

((tooth or teeth or incisor* or dental or molar* or pre-molar* or premolar* or canine*) AND (extract* or remov* or pull or "tak* out")) OR (("root canal*" or pulpectom* or pulpotom* or apicoectom* or "root end fill*" or "root end surg*" or "pulp* therap*" or "pulp* treat*")) OR ("Tooth Extraction"[mhe]) OR ("Apicoectomy"[mhe]) OR ("Pulpotomy"[mhe]) OR ("Pulpectomy"[mhe]) OR ("Root Canal Therapy"[mhe])) OR (((denture*) OR ((tooth or teeth or incisor* or dental or molar* or pre-molar* or premolar* or canine*) AND (implant* or replant* or bridge* or prosth*)) OR ("Dental Prosthesis"[mhe]) OR ("Dentures"[mhe]) OR ("Denture, Partial"[mhe]) OR ("Dental Implants"[mhe]) OR ("Dental Implantation"[mhe]) OR ("Tooth Replantation"[mhe]) OR ("Endodontics"[mhe])) AND (("irreversible pulpitis" or "pulpally involve*" or "extensive decay*" or "necrotised infection*" or "necrotized infection*" or "apical periodontitis" or "periapical periodontitis" or "periradicular periodontitis")) OR ((teeth or tooth or incisor* or molar* or pre-molar* or premolar* or canine*) AND (trauma* or avulsed or knocked or dislodg* or sublux* or injur* or displac* or

luxat*)) OR ((pulp*) AND (disease* or cavit* or inflam* or necrosis)) OR ("Tooth Injuries"[mhe]) OR ("Pulpitis"[mhe]) OR ("Dental Pulp Cavity"[mhe]) OR ("Dental Pulp Necrosis"[mhe]) OR ("Dental Pulp Diseases"[mhe]))))

Date filter applied 2015-2020 = 5 results

EMBASE (Ovid): 1974 to 2020 September 24

Searched: 25.9.20

- 1 exp tooth pulp disease/ (7056)
- 2 exp dental pulp cavity/ (1754)
- 3 pulpitis/ (2812)
- 4 tooth injury/ (5838)
- 5 ((pulp\$ adj2 (disease\$ or cavit\$ or inflam\$ or necrosis)) or ((trauma\$ or avulsed or knocked or dislodg\$ or sublux\$ or injur\$ or displac\$ or luxat\$) adj2 (teeth or tooth or incisor\$ or molar\$ or pre-molar\$ or premolar\$ or canine\$)) or "irreversible pulpitis" or "pulpally involve\$" or "extensive decay\$" or "necroti?ed infection\$" or "apical periodontitis" or "periapical periodontitis" or "periradicular periodontitis").ti,ab,kw,ot,hw. (20625)
- 6 or/1-5 (22003)
- 7 endodontics/ (24055)
- 8 tooth replantation/ (188)
- 9 exp tooth implant/ (13314)
- 10 exp tooth prosthesis/ (82764)
- 11 ((tooth or teeth or incisor\$ or dental or molar\$ or pre-molar\$ or premolar\$ or canine\$) adj2 (implant\$ or replant\$ or bridge\$ or prosthe\$)).ti,ab,kw,hw,ot. (60913)
- 12 (denture\$ or endodontic\$).ti,ab,ot,kw,hw. (81821)
- 13 or/7-12 (130333)
- 14 6 and 13 (10318)
- 15 ("root canal\$" or pulpectom\$ or pulpotom\$ or apiceotom\$).ti,ab,kw,hw,ot. (21399)
- 16 (root adj2 (fill\$ or surg\$)).ti,ab,kw,hw,ot. (11253)
- 17 ((tooth or teeth or incisor\$lar* or pre-molar* or premolar\$ or canin\$) adj2 (extract\$ or pull or "tak\$ out" or remov\$)).ti,ab,kw,hw,ot. (32373)
- 18 pulpectomy/ (164)
- 19 pulpotomy/ (323)
- 20 apiceotomy/ (1)
- 21 tooth extraction/ (22578)
- 22 "root canal obturation"/ (713)
- 23 or/18-22 (23643)
- 24 23 or 14 (33235)
- 25 shared decision making/ (7304)
- 26 ((share\$ or sharing\$ or inform\$ or patient\$) adj3 (decision\$ or deciding\$ or choice\$ or prefer\$)).ti,ab. (141634)
- 27 sdm.ti,ab. (3423)
- 28 or/25-27 (145490)
- 29 24 and 28 (198)
- 30 limit 29 to yr="2015 -Current" (72)

MEDLINE (Ovid): 1946 – 24 September 2020

MEDLINE Epub Ahead of Print, In-Process & Other Non-Indexed Citations and Daily Update (Ovid): up to 24 September 2020

Searched: 25.9.20

- 1 exp Dental Pulp Diseases/ (11168)
- 2 exp dental pulp cavity/ (9167)
- 3 pulpitis/ (2792)
- 4 tooth injuries/ (2975)
- 5 ((pulp\$ adj2 (disease\$ or cavit\$ or inflam\$ or necrosis)) or ((trauma\$ or avulsed or knocked or dislodg\$ or sublux\$ or injur\$ or displac\$ or luxat\$) adj2 (teeth or tooth or incisor\$ or molar\$ or pre-molar\$ or premolar\$ or canine\$)) or "irreversible pulpitis" or "pulpally involve\$" or "extensive decay\$" or "necroti?ed infection\$" or "apical periodontitis" or "periapical periodontitis" or "periradicular periodontitis").ti,ab,kw,ot,hw. (24248)
- 6 or/1-5 (28650)
- 7 endodontics/ (2268)
- 8 tooth replantation/ (2008)
- 9 dental implants/ (21952)
- 10 exp Dental Implantation/ (22100)
- 11 dentures/ or exp denture, partial/ (26226)
- 12 ((tooth or teeth or incisor\$ or dental or molar\$ or pre-molar\$ or premolar\$ or canine\$) adj2 (implant\$ or replant\$ or bridge\$ or prosthesis\$)).ti,ab,kw,hw,ot. (55459)
- 13 (denture\$ or endodontic\$).ti,ab,ot,kw,hw. (71229)
- 14 exp Dental Prosthesis/ (107776)
- 15 or/7-14 (143755)
- 16 6 and 15 (10660)
- 17 ("root canal\$" or pulpectom\$ or pulpotom\$ or apiceotom\$).ti,ab,kw,hw,ot. (33774)
- 18 (root adj2 (fill\$ or surg\$)).ti,ab,kw,hw,ot. (9645)
- 19 ((tooth or teeth or incisor\$lar* or pre-molar* or premolar\$ or canin\$) adj2 (extract\$ or pull or "tak\$ out" or remov\$)).ti,ab,kw,hw,ot. (31012)
- 20 exp root canal therapy/ or exp pulpectomy/ or pulpotomy/ or apicoectomy/ or tooth extraction/ (42101)
- 21 or/17-20 (63914)
- 22 16 or 21 (67304)
- 23 exp decision making/ (203846)
- 24 ((share\$ or sharing\$ or inform\$ or patient\$) adj3 (decision\$ or deciding\$ or choice\$ or prefer\$)).ti,ab. (95350)
- 25 sdm.ti,ab. (2653)
- 26 or/23-25 (284988)
- 27 22 and 26 (647)
- 28 limit 27 to yr="2015 -Current" (145)

CENTRAL (Wiley): up to issue 9, September 2020

Searched: 25.9.20

- #1 MeSH descriptor: [Dental Pulp Diseases] explode all trees 806
- #2 MeSH descriptor: [Dental Pulp Cavity] explode all trees 597
- #3 MeSH descriptor: [Pulpitis] explode all trees 318
- #4 MeSH descriptor: [Tooth Injuries] explode all trees 250

#5 ((pulp* NEAR/4 (disease* or cavit* or inflam* or necrosis)) or ((trauma* or avulsed or knocked or dislodg* or sublux* or injur* or displac* or luxat*) NEAR/4 (teeth or tooth or incisor* or molar* or pre-molar* or premolar* or canine*)) or "irreversible pulpitis" or "pulpally involve*" or "extensive decay*" or "necrotised infection*" or "necrotized infection*" or "apical periodontitis" or "periapical periodontitis" or "periradicular periodontitis"):ti,ab,kw 2309

#6 #1 or #2 or #3 or #4 or #5 2657

#7 MeSH descriptor: [Endodontics] explode all trees 1395

#8 MeSH descriptor: [Tooth Replantation] explode all trees 17

#9 MeSH descriptor: [Dental Implants, Single-Tooth] explode all trees 314

#10 MeSH descriptor: [Dental Implantation] explode all trees 1222

#11 MeSH descriptor: [Denture, Partial] explode all trees 350

#12 MeSH descriptor: [Dentures] explode all trees 980

#13 MeSH descriptor: [Dental Prosthesis] explode all trees 4267

#14 (((tooth or teeth or incisor* or dental or molar* or pre-molar* or premolar* or canine*) NEAR/4 (implant* or replant* or bridge* or prosth*)) or denture*):ti,ab,kw 5100

#15 #7 #8 or #9 or #10 or #11 or #12 or #13 or #14 6911

#16 #6 and #15 453

#17 MeSH descriptor: [Root Canal Therapy] explode all trees 1082

#18 MeSH descriptor: [Pulpectomy] explode all trees 81

#19 MeSH descriptor: [Pulpotomy] explode all trees 159

#20 MeSH descriptor: [Apicoectomy] explode all trees 83

#21 MeSH descriptor: [Tooth Extraction] explode all trees 1748

#22 ("root canal*" or pulpectom* or pulpotom* or apicoectom* or (root NEAR/2 fill*) or (root NEAR/2 surg*) or (pulp* NEAR/2 (therap* or treat*))) :ti,ab,kw 3267

#23 (tooth or teeth or incisor* or dental or molar* or pre-molar* or premolar* or canine*) NEAR/4 (extract* or remov* or pull or "tak* out"):ti,ab,kw 6236

#24 #17 or #18 or #19 or #20 or #21 or #22 or #23 8921

#25 #16 or #24 9061

#26 MeSH descriptor: [Decision Making] explode all trees 3861

#27 ((share* or sharing* or inform* or patient*) NEAR/3 (decision* or deciding* or choice* or prefer*)) :ti,ab,kw 15902

#28 sdm:ti,ab 385

#29 #26 or #27 or #28 19008

#30 #25 and #29 with Publication Year from 2015 to 2020, in Trials 27

The following resources were searched on 1.10.20 and scanned for relevant guidelines:

- **European Society of Endodontology** (<https://www.e-s-e.eu/index.html>)
Home – Publications
3 results
- **British Endodontic Society** (<https://britishendodonticsociety.org.uk/>)
Home – Endodontic publications
1 result
- **American Association of Endodontists** (<https://www.aae.org/>)

Home – Professional site – Clinical Resources – Guidelines & Position Statements
6 results

- **German Society of Endodontology and Traumatology** (<https://www.dget.de/fuer-zahnaerzte/wissenschaftliche-mitteilungen>)

Home – For dentists – Scientific communications
2 results

- **Scottish Dental Clinical Effectiveness Programme**
(<https://www.sdcep.org.uk/published-guidance/>)

0 results

- **American Dental Association** (<https://www.ada.org/en>)

Home – Clinical Resources – Clinical Practice Guidelines
1 result

APPENDIX 2: KEY FOR DECISION AID

Type of Arrow	Assessment for use in DA
↑	“Proof or strong indication of effect” Difference in favour of group A versus B based on high to moderate quality data* The effect estimate ideally should be significant, but may sometimes be only borderline significant but from several studies indicating a trend (that according to KSR should be mentioned) Our Medical Writers will use these effects/numbers as reported for our DA.
↗	“Indication or hint of effect” Difference in favour of group A versus B based on low quality data that appears reportable in the DA (e.g., large effect on survival based on registry data, consistently very convincing effects from observational studies supported by one small RCT with same direction of effect) Our Medical Writers will have to decide together with the evidence team whether and how the effects/numbers will be reported in DA.
↔	“No Proof/Indication of effect or a hint of effect that is too weak to report” No difference shown among groups based on moderate to high quality data or difference shown but does not seem reliable enough to be reported based on low or very low quality data Our Medical Writers may report the numbers (if available; to provide some idea on frequency) – same for the groups (average or range) - and acknowledge that no difference between groups was shown (yet).
.	No data to report: no difference shown from low/very low quality studies or no studies Our Medical Writers will not report on these effects/numbers
	↓ Proof of harm, i.e., risks outweigh benefits

*The term “Data Quality” includes assessment of evidence (level of evidence, risk of bias assessment) as well as transferability of study results to our target population. This should be either taken from original reviews/meta-analyses or provided by KSR for studies where no external evidence assessment exists.

APPENDIX 3: ROBIS TABLE

Review	Phase 2			Phase 3	
	1. STUDY ELIGIBILITY CRITERIA	2. IDENTIFICATION AND SELECTION OF STUDIES	3. DATA COLLECTION AND STUDY APPRAISAL	4. SYNTHESIS AND FINDINGS	RISK OF BIAS IN THE REVIEW
Chrcanovic 2015 ⁴	😊	😊	😞	😞	😞
Cosyn 2019 ³	😊	😊	😊	😊	😊
Chercoles-Ruiz 2017 ¹	😊	😊	😞	😞	😞
Sun 2018 ²	😊	😊	😊	😊	😊
Antunes 2018 ¹⁵	😊	😞	😞	NA	😞
Olivieri 2020 ¹²	😊	😞	?	😞	😞
Kohli 2018 ¹⁶	😞	😞	😞	😞	😞
Torabinejad 2015 ⁶	😊	😞	😞	😊	😞
Torabinejad 2015 ¹⁷	😞	😞	😞	😞	😞
Del Fabbro 2016 ¹³	😊	😊	😊	😊	😊
Manfredi 2016 ¹⁴	😊	😊	😊	😊	😊
Leong 2020 ¹⁰	😊	😞	?	😊	😞

😊 = low risk; 😞 = high risk; ? = unclear risk

APPENDIX 4: DE NOVO META-ANALYSIS DATA

Root end resection, radiological/clinical/global failure, from Chercoles-Ruiz 2017¹

Author, Year	Events	N	Percent Failure
Barone, 2010	30	106	28.0%
Caliskan, 2015	13	90	14.4%
Kreisler, 2013	34	281	12.0%
Lui, 2014	20	93	21.5%
Penarrocha, 2007	48	333	14.4%
Saunders, 2008	31	276	11.2%
Song, 2011	2	42	4.8%
Song, 2011	67	441	15.2%
Song, 2014	13	115	11.3%
Taschieri, 2007	1	28	3.5%
Taschieri, 2008 (Endoscope)	4	50	7.3%
Taschieri, 2008 (Microscope)	3	63	5.0%
Taschieri, 2009	3	43	7.0%
Tortorici, 2014 (1)	27	458	6.0%
Tortorici, 2014 (2)	6	206	3.0%
Tortorici, 2014 (3)	3	273	1.0%
Von Arx, 2012	22	170	12.9%
Walivaara, 2007	11	55	20.0%
Walivaara, 2011 (IRM)	9	96	9.4%
Walivaara, 2011 (SuperEBA)	18	98	18.4%
All studies (n=20)	364	3,317	10.78% (95% CI: 7.78% to 13.77%)

Root Canal Therapy, radiological/clinical/global failure, from Chercoles-Ruiz 2017¹

Author, Year	Events	N	Percent Failure
Chen, 2007	110,586	1,557,547	7.1%
Craveiro, 2015	78	523	15.0%
De Chevigny, 2008	21	126	17.0%
Doyle, 2006	12	196	6.1%
Fleming, 2010 (Classic ET)	9	459	2.0%
Fleming, 2010 (Contemporary ET)	21	525	4.0%
Fonzar, 2009	68	1,175	5.8%
Fransson, 2016	25,326	248,299	10.2%
Gomes, 2015	660	1,290	51.2%
Hannahan, 2008	1	143	0.7%
Landys-Boren, 2015	29	420	6.8%
Marquis, 2006	18	132	14.0%
Ng, 2011 (ET)	35	759	4.6%
Ng, 2011 (Re-ET)	41	858	4.8%
Ricucci, 2011	89	816	10.9%
Salehrabi, 2010	522	4,744	11.0%
Vozza, 2013	7	42	16.7%
All studies (n=17)	137,525	1,818,054	9.98% (95% CI: 8.57% to 11.39%)

Implant, radiological/clinical/global failure, from Chercoles-Ruiz 2017¹

Author, Year	Events	N	Percent Failure
Bonde, 2010	3	52	6.0%
Cha, 2013	11	136	8.1%
Covani, 2012	13	159	8.2%
Covani, 2014	2	47	4.3%
Doyle, 2006	12	196	6.1%
Gotfredsen, 2012	0	10	0.0%
Hannahan, 2008	2	129	1.6%
Koo, 2010	26	521	4.9%
Levin, 2006	96	1,387	6.9%
Luongo, 2014	1	57	1.5%
Vanlioglu, 2014	0	55	0.0%
Vozza, 2013	9	47	19.2%
Wennstrom, 2005	1	40	2.5%
All studies (n=13)	176	2,836	4.78% (95% CI: 3.05% to 6.51%)

Root canal therapy (by tools used), risk of pain, from Sun 2018²

Author, Year	Arm	Events	N	Percent Pain
Al-Jabreen, 2002 (a)	Manual	8	35	22.9%
Al-Jabreen, 2002 (b)	Manual	8	35	22.9%
Arias, 2015	Manual	31	44	70.5%
Du, 2016	Manual	11	26	42.3%
Kashefinejad, 2016	Manual	29	30	96.7%
Zhang, 2013	Manual	45	197	22.8%
All manual tool studies (n=6)	Manual	132	367	46.46% (95% CI: 13.73% to 79.19%)
Du, 2016	Reciprocating	2	30	6.7%
Gambarini, 2012	Reciprocating	20	30	66.7%
Gambarini, 2013	Reciprocating	21	30	70.0%
Neelakantan (2015)	Reciprocating	98	605	16.2%
Shivanna, 2015 (a)	Reciprocating	29	30	96.7%
Shivanna, 2015 (b)	Reciprocating	29	30	96.7%
All reciprocating tool studies (n=6)	Reciprocating	199	755	58.74% (95% CI: 20.05% to 97.43%)
Al-Jabreen, 2002 (a)	Rotary	1	35	2.9%
Al-Jabreen, 2002 (b)	Rotary	2	35	5.7%
Arias, 2015	Rotary	22	44	50.0%
Du, 2016	Rotary	3	30	10.0%
Gambarini, 2012	Rotary	15	30	50.0%
Gambarini, 2013	Rotary	16	30	53.3%
Kashefinejad, 2016	Rotary	13	30	43.3%
Neelakantan (2015)	Rotary	143	605	23.6%
Shivanna, 2015 (a)	Rotary	22	30	73.3%
Shivanna, 2015 (b)	Rotary	19	30	63.3%
Zhang, 2013	Rotary	7	198	3.5%
All rotary tool studies (n=11)	Rotary	263	1,097	32.43% (95% CI: 21.38% to 43.48%)
All studies (n=23)	Any tool	594	2,219	43.67% (95% CI: 30.07% to 57.27%)

Root canal therapy (manual tools), VAS (visual analogue scale) pain, from Sun 2018²

Time	Author & year	N	Mean	SD
6-8 hours	Kashefinejad, 2016	30	3.66	3.52
6-8 hours	Mollashashi, 2017	50	5.00	2.78
All 6-8 hours studies (n=2)		80	4.47 (95% CI: 3.13 to 5.73)	
12 hours	Kashefinejad, 2016	30	3.53	3.7
12 hours	Mollashashi, 2017	50	3.88	2.6
All 12 hours studies (n=2)		80	3.80 (95% CI: 3.17 to 4.43)	
24 hours	Kashefinejad, 2016	30	2.46	3.32
24 hours	Mollashashi, 2017	50	2.76	2.29
All 24 hours studies (n=2)		80	2.69 (95% CI: 2.13 to 3.25)	

Root canal therapy (rotary tools), VAS (visual analogue scale) pain, from Sun 2018²

Time	Author & year	N	Mean	SD
6-8 hours	Kashefinejad, 2016	30	1.00	2.16
6-8 hours	Mollashashi, 2017	50	3.50	2.91
All 6-8 hours studies (n=2)		80	2.25 (95% CI: -0.20 to 4.70)	
12 hours	Kashefinejad, 2016	30	0.37	1.72
12 hours	Mollashashi, 2017	50	1.70	2.17
All 12 hours studies (n=2)		80	1.04 (95% CI: -0.27 to 2.34)	
24 hours	Kashefinejad, 2016	30	0.86	2.19
24 hours	Mollashashi, 2017	50	0.82	1.52
All 24 hours studies (n=2)		80	0.83 (95% CI: 0.46 to 1.20)	

Immediate implant, failure (converted from survival), from Cosyn 2019³

Author, Year	Events	N	Percent Failure
Atieh, 2013	4	12	33.3%
Cooper, 2014	3	55	5.5%
Cucchi, 2017	2	49	4.1%
Lindeboom, 2006	2	25	8.0%
Mangano, 2013	0	22	0.0%
Raes, 2018	1	16	6.3%
Siciliano, 2009	0	15	0.0%
Tonetti, 2017	1	62	1.6%
All studies (n=8)	13	256	3.14% (95% CI: 0.43% to 5.85%)

Delayed implant, failure (converted from survival), from Cosyn 2019³

Author, Year	Events	N	Percent Failure
Atieh, 2013	2	12	16.7%
Cooper, 2014	1	58	1.7%
Cucchi, 2017	0	48	0.0%
Lindeboom, 2006	0	25	0.0%
Mangano, 2013	0	18	0.0%
Raes, 2018	0	23	0.0%
Siciliano, 2009	0	15	0.0%
Tonetti, 2017	0	62	0.0%
All studies (n=8)	3	261	0.36% (95% CI: 0% to 1.74%)

Immediate implant, complications, from Cosyn 2019³

Author, Year	Events	N	Percent Complications
Atieh, 2013	4	12	33.3%
Cucchi, 2017	0	49	0.0%
Mangano, 2013	0	22	0.0%
Raes, 2018	6	16	37.5%
All studies (n=4)	10	99	8.16% (95% CI: 0% to 18.14%)

Delayed implant, complications, from Cosyn 2019³

Author, Year	Events	N	Percent Complications
Atieh, 2013	3	12	25.0%
Cucchi, 2017	0	48	0.0%
Mangano, 2013	0	18	0.0%
Raes, 2018	5	23	21.7%
All studies (n=4)	8	101	5.83% (95% CI: 0% to 14.32%)

Socket (immediate) implant, complete loss of the implant, from Chrcanovic 2015⁴

Author, Year	Events	Total	Failure Percent
Mensdorff-Pouilly, 1994	7	93	7.5%
Watzek, 1995	1	97	1.0%
Haas, 1996	7	96	7.3%
Gomez-Roman, 1997	1	86	1.2%
Callan, 2000	8	331	2.4%
Polizzi, 2000	14	217	6.5%
Malo, 2000	4	27	14.8%
Chaushu, 2001	3	17	17.6%
Arlin, 2002	22	491	4.5%
De Bruyn , 2002	12	31	38.7%
Aires, 2002	1	29	3.4%
Wolfinger, 2003	2	82	2.4%
Malo, 2003	2	45	4.4%
Malo, 2003	0	22	0.0%
Kourtis, 2004	17	182	9.3%
Perry, 2004	32	322	9.9%
Locante, 2004	1	46	2.2%
Jaffin, 2004	7	121	5.8%
Norton, 2004	0	16	0.0%
Evian, 2004	15	100	15.0%
Dhanrajani, 2005	2	8	25.0%
Davarpanah, 2005	3	68	4.4%
Lindeboom, 2006	2	25	8.0%
Degidi, 2006	5	67	7.5%
Horwitz, 2007	10	42	23.8%
Degidi, 2007	4	416	1.0%
Degidi, 2007	2	36	5.6%
Ribeiro, 2008	3	46	6.5%
Ormianer, 2008	3	91	3.3%
Penarrocha-Diago, 2008	0	32	0.0%
Sennerby, 2008	1	18	5.6%
Irinakis, 2009	0	37	0.0%
Pieri, 2009	1	59	1.7%
van Kesteren, 2010	1	13	7.7%
Deng, 2010	4	32	12.5%
Alves, 2010	0	108	0.0%
Artzi, 2010	13	367	3.5%
Cannizzaro, 2010	4	10	40.0%
Siebers, 2010	4	58	6.9%
Zafiropoulos, 2010	9	153	5.9%
Bogaerde, 2010	1	16	6.3%
Cooper, 2010	3	58	5.2%

Felice, 2011	2	54	3.7%
Bae, 2011	0	26	0.0%
Mertens, 2011	0	7	0.0%
Malchiodi, 2011	6	138	4.3%
Cavallaro, 2011	1	28	3.6%
Aguirre-Zorzano, 2011	1	56	1.8%
Penarrocha-Diago, 2011	4	173	2.3%
Gillot, 2011	4	182	2.2%
Ji, 2012	7	31	22.6%
Covani, 2012	0	119	0.0%
Raes, 2012	1	48	2.1%
Romanos, 2012	0	25	0.0%
Penarrocha-Oltra, 2012	1	35	2.9%
Ormianer, 2012	0	65	0.0%
Vandeweghe, 2012	3	69	4.3%
Gillot, 2012	5	352	1.4%
Penarrocha-Diago, 2012	22	480	4.6%
Urdaneta, 2012	5	159	3.1%
Cannizzaro, 2012	0	18	0.0%
Cosyn, 2012	1	77	1.3%
Degidi, 2012	6	1,184	0.5%
De Bruyn , 2013	3	55	5.5%
Cosyn, 2013	2	30	6.7%
Piek, 2013	5	123	4.1%
Penarrocha-Oltra, 2013	4	94	4.3%
Atieh, 2013	4	12	33.3%
Raes, 2013	1	16	6.3%
Luongo, 2014	0	10	0.0%
Cakarar, 2014	0	94	0.0%
Meizi, 2014	7	215	3.3%
Cooper, 2014	3	55	5.5%
All studies (n=73)	329	8,241	3.32% (95% CI: 2.62% to 4.03%)

Healed (delayed) implant, complete loss of the implant, from Chrcanovic 2015⁴

Author, Year	Events	Total	Failure Percent
Mensdorff-Pouilly, 1994	5	97	5.2%
Watzek, 1995	2	37	5.4%
Haas, 1996	72	1,725	4.2%
Gomez-Roman, 1997	17	446	3.8%
Callan, 2000	7	769	0.9%
Polizzi, 2000	3	47	6.4%
Malo, 2000	0	67	0.0%
Chausu, 2001	0	9	0.0%
Arlin, 2002	117	2,283	5.1%
De Bruyn , 2002	1	153	0.7%
Aires, 2002	1	46	2.2%
Wolfinger, 2003	3	62	4.8%
Malo, 2003	3	131	2.3%
Malo, 2003	5	94	5.3%
Kourtis, 2004	62	1,692	3.7%
Perry, 2004	71	777	9.1%
Locante, 2004	0	40	0.0%
Jaffin, 2004	9	115	7.8%
Norton, 2004	1	12	8.3%
Evian, 2004	7	49	14.3%
Dhanrajani, 2005	7	139	5.0%
Davarpanah, 2005	1	80	1.3%
Lindeboom, 2006	0	25	0.0%
Degidi, 2006	0	44	0.0%
Horwitz, 2007	2	32	6.3%
Degidi, 2007	4	658	0.6%
Degidi, 2007	1	97	1.0%
Ribeiro, 2008	0	36	0.0%
Ormianer, 2008	1	174	0.6%
Penarrocha-Diago, 2008	4	130	3.1%
Sennerby, 2008	5	99	5.1%
Irinakis, 2009	2	70	2.9%
Pieri, 2009	1	85	1.2%
van Kesteren, 2010	0	13	0.0%
Deng, 2010	0	52	0.0%
Alves, 2010	2	60	3.3%
Artzi, 2010	8	309	2.6%
Cannizzaro, 2010	1	30	3.3%
Siebers, 2010	1	164	0.6%
Zafiropoulos, 2010	2	99	2.0%
Bogaerde, 2010	0	53	0.0%
Cooper, 2010	1	65	1.5%

Felice, 2011	0	52	0.0%
Bae, 2011	1	54	1.9%
Mertens, 2011	1	42	2.4%
Malchiodi, 2011	2	101	2.0%
Cavallaro, 2011	1	176	0.6%
Aguirre-Zorzano, 2011	0	22	0.0%
Penarrocha-Diago, 2011	4	119	3.4%
Gillot, 2011	4	266	1.5%
Ji, 2012	14	180	7.8%
Covani, 2012	8	45	17.8%
Raes, 2012	1	54	1.9%
Romanos, 2012	3	85	3.5%
Penarrocha-Oltra, 2012	4	88	4.5%
Ormianer, 2012	1	108	0.9%
Vandeweghe, 2012	1	24	4.2%
Gillot, 2012	1	323	0.3%
Penarrocha-Diago, 2012	21	542	3.9%
Urdaneta, 2012	4	250	1.6%
Cannizzaro, 2012	2	42	4.8%
Cosyn, 2012	38	1,021	3.7%
Degidi, 2012	22	2,951	0.7%
De Bruyn , 2013	1	58	1.7%
Cosyn, 2013	5	82	6.1%
Piek, 2013	7	337	2.1%
Penarrocha-Oltra, 2013	0	99	0.0%
Atieh, 2013	2	12	16.7%
Raes, 2013	0	32	0.0%
Luongo, 2014	1	47	2.1%
Cakarar, 2014	15	846	1.8%
Meizi, 2014	3	129	2.3%
Cooper, 2014	1	58	1.7%
All studies (n=73)	597	19,410	2.27% (95% CI: 1.77% to 2.76%)