

## Implant based versus endodontic treatment concepts for anterior teeth

### Porównanie koncepcji leczenia implantologicznego względem endodontycznego zębów w odcinku przednim

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#### Abstract

**Introduction.** Patients expect not only a fully functional restoration, but also an aesthetically pleasing and a long-lasting solution. Especially in the anterior region, aesthetics plays a vital role in treatment. Therefore, a practitioner needs to make a considerate choice between any treatment modality.

**Aim of the study.** The aim of this paper is to present and compare methods of treating the anterior teeth in the aesthetic area, especially to compare root canal treatment (RCT) as opposed to implant-supported crowns (ISC) as far as their effectiveness, longevity and possible complications are concerned.

**Material and methods.** PubMed and Medline were queried for all studies that compared non surgical root canal therapy and restoration with the extraction of teeth and placement of a dental implant. The full text of 58 articles related to the studied subject were analysed.

**Results.** The effectiveness of implant and endodontic therapy is similar only in the first 6 years after treatment is completed. Over time a significant decrease in survival rates is observed for endodontically treated teeth, while for implants this fall is markedly lower.

**Conclusions.** 1. A dentist should present to a patient both methods, their advantages, disadvantages and risks. 2. If RCT is risky due to root canal anatomy, especially in multi-rooted teeth, the implant option should be considered. The expected aesthetic effects should be considered, especially in the anterior area. Implant insertion does not always give a favourable and expected aesthetic result if this is not preceded by gingival and bony tissue preparation. The bony and soft tissue quality should be considered. Any bone density abnormalities or bone deficits seen on radiograms should help a dentist decide on RCT procedures or bone augmentation. 3. Properly done implanto-prosthetics preceded by a detailed analysis of the underlying tissues, of radiograms, and of diagnostic models should result in restoring the anatomical and physiological function of the lost tooth. 4. The decision on RCT or implant treatment should be taken following consultation from specialists in both these modalities and an assessment of the restoration survival time for both methods.

**Key words:** root canal therapy, dental implants, survival rate.

#### Streszczenie

**Wstęp.** Oczekiwania pacjentów dotyczą nie tylko przywrócenia funkcji zgryzowych, ale również trwałych i estetycznych rozwiązań. Szczególnie w odcinku przednim, gdzie estetyka odgrywa istotną rolę w leczeniu. Zatem lekarz musi dokonać odpowiedniego wyboru między poszczególnymi metodami leczenia.

**Cel pracy.** Celem niniejszego artykułu jest przedstawienie i porównanie metod leczenia zębów przednich w obszarze estetycznym. Przedstawiono przede wszystkim porównanie leczenia endodontycznego (RCT) względem leczenia implantologicznego (ISC) w zakresie efektywności, trwałości i ewentualnych powikłań.

**Materiał i metody.** W celu porównania chirurgicznego leczenia endodontycznego względem ekstrakcji zęba i implantacji, dokonano przeglądu literatury Pub Med i Medline. Do poniższych badań i analizy porównano pełen tekst 58 artykułów.

**Wyniki i wnioski.** 1. Lekarze powinni przedstawić pacjentowi obie metody leczenia, ich zalety, przeciwwskazania oraz możliwe powikłania. 2. Jeżeli RCT jest ryzykowne ze względu na anatomie kanałów korzeniowych, szczególnie w zębach wielokorzeniowych, leczenie implantologiczne powinno zostać rozważone. W odcinku przednim należy zwrócić uwagę na oczekiwania estetyczne pacjentów. Wprowadzenie implantu nie zawsze daje oczekiwany efekt estetyczny, jeżeli nie jest poprzedzone odpowiednią preparacją kości i dziąsła. Należy wziąć pod uwagę jakość kości przylegającego dziąsła. Każda nieprawidłowość gęstości lub deficyt kości na radiogramie powinien pomóc lekarzowi w decyzji dotyczącej wyboru procedury leczenia endodontycznego (RCT) lub augmentacji kości. 3. Prawidłowo przeprowadzone leczenie implantoprotetyczne, poprzedzone dokładną analizą przylegających tkanek, radiogramów i modeli diagnostycznych, powinno doprowadzić do odtworzenia anatomicznych i fizjologicznych funkcji utraconego zęba. 4. Decyzja odnośnie do wyboru metody leczenia endodontycznego (RCT) czy implantu powinna zostać podjęta przez specjalistów obu specjalności, po ocenie czasu przetrwania obu metod.

**Słowa kluczowe:** leczenie kanałowe, implanty stomatologiczne, przetrwanie.

## Introduction

How to restore teeth in the anterior (aesthetic) region is an essential therapeutic issue today, in an era of intensive developments in treatment concepts. Often practitioners (and patients) are faced with a decision: to try and preserve the natural dentition using root canal procedures (RCT) and restorations; to extract the tooth and replace it with an implant and an implant-supported single crown (ISC); or to resort to prosthodontic procedures. Not only is the choice difficult, but there is also much controversy about the effectiveness of these modalities.

In recent years there have been visible developments in endodontics, both theoretical and practical, as well as in the underlying technologies and materials. Endodontists today use advanced treatment concepts, and an endodontic treatment is a very effective treatment option, which is reflected in the literature and clinical data.

However, there are doubts about the effectiveness of root canal treatments [1, 2], which refer to the survival time of an RCT-treated tooth; to its aesthetics, especially in the front region (an RCT-treated tooth may darken over time); or to post-therapeutic complications. A repeated endodontic treatment of the same tooth (the so-called re-endo) is difficult and may be unsuccessful.

Moreover, as a result of wrong and unnecessarily long endodontic treatments complications often appear, which not only bring about the necessity of removing the tooth, but may also complicate any implant treatment due to alveolar bone destruction or infected and destroyed mucosal tissues.

Implant treatment seems to be the optimal solution in the event of the failure of canal procedures. Many authors claim that inserting an implant can be justified for clinical or aesthetic reasons, especially in the anterior region. However, it has to be kept in mind that tooth implantation is a surgical procedure where there is a risk of both early and late complications. Similarly in endodontic treatment, there are questions and doubts concerning the effectiveness and aesthetical outcome of this therapy as well as the survival of the restored teeth.

## Material and methods

The current literature was identified and reviewed, covering two treatment options for the endodontic treatment of teeth: root canal therapy (RCT) and restoration; versus, extraction and placement of a dental implant with an implant supported single crown (ISC). PubMed and Medline were queried for all studies that compared nonsurgical root canal therapy and restoration with the extraction of teeth and the placement of a dental implant. The search was guided by key words such as "root canal therapy", "dental implants", "survival rate". This search was supplemented by searching the bibliographies of these articles to ensure that all relevant studies were included. The literature is discussed in terms

of the outcomes for both treatment options, considerations for treatment plan decision-making and complications in the opinions of the authors.

Table 1 shows what subjects were looked for in the key word guided search.

Table 2 shows where the search was performed. PubMed/Medline shows the internet pages searched for scientific publications. By *Manual search* is meant a scrutiny of the publications available at the Karol Marcinkowski Medical University Library, Poznań, Poland.

Table 3 presents the method for the further verification of the initially chosen materials. This was done in two stages. First, among the articles found whose titles included the chosen key word, those were rejected which – despite being classified under a given key word – did not relate to the subject. Secondly, the full text of the remaining publications were analysed, out of which some were rejected due to their divergence from the subject or because they were irrelevant to the search.

## Results

Torabinejad demonstrated that both pooled and weighted (factoring in sample sizes) success rates were consistently higher for implant therapy than for endodontic treatment. Additionally, root canal and implant-supported single crowns had superior psychosocial outcomes, primarily with respect to patient self-image, compared to extraction without replacement [3].

**Table 1.** Subject-related literature screening

**Tabela 1.** Analiza literatury pod względem zagadnienia

Chosen issues	Number of articles
Root canal therapy	19
Dental implants	60
Root canal therapy versus dental implants	27
Total	106

**Table 2.** Source-related literature screening

**Tabela 2.** Analiza literatury względem źródła

PubMed/Medline	83
Manual search	23
Total	106

**Table 3.** The two-step procedure

**Tabela 3.** Dwustopniowa procedura weryfikacji publikacji

1st step: screening of 106 titles and abstracts:	
– Non-English language publications	9
– English language publication	97
– Not related to the studied subject (excluded from further analysis)	14
2nd step: full text of 92 articles analysed:	
– Chosen for analysis	58
– Not related to the studied subject (excluded from further analysis)	34

## Statistical Methods

Table 4 shows a comparison of two treatment methods for anterior teeth. Pooled and weighted success and survival rates, with their associated 95% confidence intervals (CI), were calculated using the DerSimonian-Laird random effects model. The data is based on the study presented by Torabinajad et al. [4].

## Results

### Dental implants

The studies by Scheller, Creugers, and Lindh et al. have reported five-year implant survival rates upwards of 95 percent [5, 6, 7].

Pennington et al., using the Markov's model, forecasts superior survival for an ISC over a conventional root canal treated tooth with a postcrown. After 20 years around 25% of root canal treated and re-treated teeth were estimated to have been lost, whereas only 10% of first implants had failed, necessitating a further implant or replacement with a bridge or denture [8].

Iqbal & Kim restricted their outcome measure to 'survival', which was defined as the clinically observed presence of the root canal treated tooth or implant in the mouth. With proportional estimates for survival of 94% for RCT and 96% for implant-supported single crowns (ISC) after 5 years, and 97% (RCT) and 94% (ISC) after 6 years the review did not reveal any differences between the two treatment modalities [9].

Hannah and Eleazer performed a comparison between a group of 129 implants and 143 endodontically treated teeth. Success was recorded if the implant or tooth was in place and functional. The result for implants after an average of 36 months was 98.4%, and for root canal treated teeth after an average of 22 months – 99.3% [10].

Doyle et al. compared 196 root canal treated teeth with 196 implants, taking into account success, survival, survival with subsequent treatment intervention, and failure. Survival rates were 73.1% and 82.1%, respectively [11] (Table 5).

### Root canal therapy

Bader claimed in his paper that the three-year success rate for endodontic treatment in resolving pulpal or periapical disease was 98 percent [12].

However, Weibner claims that when performed by specialist endodontists, success rates are between 70% and 95% [13]. The data reported by clinicians are lower and are in the range of 64% to 75% [14].

Caplan and Weintraub evaluated the loss of teeth following nonsurgical endodontic therapy and found a survival rate of 67% after 5 years and 56% after 8 years [15] (Table 6).

### Complications following RCT and implants insertion

In 2006 Doyle et al, compared initial nonsurgical RCT and single tooth implants (STI) in a retrospective cross-sectional analysis. Similar failure rates (6%) were reported for both treatments, but significantly more implants required some type of post-treatment intervention. Hence, clinical complications were observed in 18% of the restored implant cases and 4% amongst the RCT teeth. In RCT teeth, these complications were mainly related to endodontic retreatment or persistent apical periodontitis (AP) as assessed from radiographs; whilst in implants, several technical problems occurred or surgical interventions were required to treat peri-implantitis.

Lazarski et al., Salehrabi and Rotstein, and Chen et al. noted that eight years after initial nonsurgical root canal treatment, 96% of all teeth (almost 1.5 mil-

**Table 4.** Comparison of two treatment methods for anterior teeth

**Tabela 4.** Porównanie obu metod leczenia w odcinku przednim

Method	Years Publisher	Sample Size	Time in years	Pooled Survival Rate (95% CI)	Weighted Survival Rate (95% CI)
ISC	1993–2005	1238	2–4	95 (93–97)%	96 (94–97)
	1996–2004	915	4–6	97 (95–98)%	97 (95–99)
	1999–2005	1308	6+	97 (95–98)%	97 (96–98)
RCT	1979–2006	2310	2–4	90 (88–92)%	89 (88–91)
	2000–2006	732	4–6	93 (87–97)%	94 (92–96)
	2005–2006	791	6+	84 (82–87)%	84 (81–87)

**Table 5.** Comparing the results for implant treatment

**Tabela 5.** Porównanie wyników leczenia implantologicznego

Author	Time of study in years	Survival Rate (%)
Scheller et al., Creugers et al., Lindh et al.	5	95
Swartz et al.	10	90
Pennington (Markov model)	20	90
Iqbal and Kim	5	96
	6	94
Hannah and Eleazer	3	98.4
Doyle et al.	–	82.1

**Table 6.** Comparing the results for endodontic treatment**Tabela 6.** Porównanie wyników leczenia endodontycznego

Author	Time of study in years	Survival rate (%)
Pennington (Markov model)	20	75
Iqbal and Kim	5 6	94 97
Bader et al.	3	98
Weibner et al.	– –	70–95 64–75
Caplan and Weibner	5 8	65 56
Hannahan and Eleazer	1.8	99.3
Doyle et al.	–	73.1

lion) were retained without any untoward event; 0.4% required nonsurgical retreatment; in 0.6% apical surgery was performed; and 2.9% were extracted.

Chen et al. also reported a high 5-year tooth retention rate of 93% following nonsurgical RCT in more than 1.5 million teeth. In all, almost 10% were affected by untoward events (6.9% of the teeth were extracted, 2.3% required nonsurgical retreatment, and in 0.5% apical surgery was performed) [9].

Caplan and Weintraub claimed that for a root canal treated tooth the indications for extraction were periodontal disease (22%), vertical root fracture (20%), dental caries (16%), nonrestorable tooth fracture (10%), and unknown (32%) [15].

### Study analysis

See Table 7.

### Aesthetic zone

One of the most important problems that occurs in ISC but does not in RCT is marginal bone resorption. During the first year following implant placement, bone remodelling may cause bone resorption in the marginal area (average 1.3–1.5 mm around implants placed at the bone level) [20]. Berglundh et al. stated that any further bone loss, particularly reaching > 2.5 mm, is considered as disease manifestation and affects at least 28% of implants [21]. Albrektsson et al. evaluated a maximum of 2.3 mm bone loss after 5 years of function [22].

### Discussion

Torabinajad, comparing the clinical outcomes of restored endodontically treated teeth with those of implant-supported restorations, concluded that survival rates of restored endodontically treated teeth and single implants are similar with some advantage for implants, but that the decision to treat a tooth endodontically or replace it with an implant must be based on factors other than the treatment outcomes of the procedures themselves [23].

However, comparing the survival rates of ISC and RCT included in Tables 4–6, formulated based on the studies of other researchers, it can be claimed

**Table 7.** The results of research presented by the authors in the literature studied**Tabela 7.** Wyniki badań prezentowane przez autorów w analizowanej literaturze

Authors	Year	Field of Study	Study Type	Sample	Relevant Findings
Gatten et al. [16]	2011	RCT vs ISC	Cross-sectional	48	This study shows a high rate of satisfaction with both treatment modalities
Setzer et al. [17]	2011	RCT outcomes	Retrospective 4 years	50	The only preoperative factors significant for the prognosis of restored endodontically treated teeth were related to periodontal prognostic value and attachment loss.
Pennington et al. [9]	2009	RCT vs ISC	Prospective	No data	Modelling the available clinical and cost data indicates that root canal treatment is highly cost-effective as a first line intervention. Orthograde re-treatment is also cost-effective, if a root treatment subsequently fails, but surgical re-treatment is not. Implants may have a role as a third line intervention if retreatment fails.
Hannahan and Eleazer [10]	2008	RCT vs ISC	Retrospective ISC 36 months RTC 22 months	129 Implants 143 Teeth	The success of implant and endodontically treated teeth was essentially identical, but implants required more postoperative treatments to maintain them.
Doyle et al. [11]	2006	RCT vs ISC	Retrospective	196 Implants 196 teeth	Both methods show similar failure rates; implant group showed a longer average and median time to function and a higher incidence of post-operative complications requiring subsequent treatment intervention.
Buser et al. [18]	2009	ISC; aesthetic outcomes	Prospective 12 months	20 patients	The study evaluating the concept of early implant placement demonstrated successful tissue integration for all 20 implants. The short-term follow-up of 12 months revealed pleasing aesthetic outcomes
Buser et al. [19]	2011	ISC; aesthetic outcomes	Prospective 3 years	20 patients	The midterm 3-year follow-up revealed pleasing aesthetic outcomes and stable facial soft tissues. The risk of mucosal recession was low, with only one patient showing minor recession of the facial mucosa.
Pennington et al. [9]	2009	RCT vs ISC	Prospective	No data	Root canal treatment extended the life of the tooth at an additional cost of £5–8 per year of tooth life, implant of £12–15 per year

that the implant and endodontic therapy effectiveness is similar only in the first 6 years after treatment is completed. Over time a significant decrease in survival rate is observed for endodontically treated teeth (a fall from 99.3% after 1.8 years to 75% after 20 years); while for implants this fall is markedly lower (from 96% after 2 years to 90% after 20 years). A large difference was also noted between individual authors in their estimate of the survival rate for endodontic therapy (Caplain and Weiber give 65% after 5 years, while Iqbal and Kim give 94% after 5 years). However, the difference in the survival of ISC is small and the results in various papers are close to 90%.

So why an implant in the aesthetic zone?

Long-term implant survival rates better than 90% are well supported in the literature [24–28], which is shown in Tables 4 and 5. Modern implant surfaces provide more predictable integration (measured by bone-implant contact, removal torque, and resonance frequency) at every time interval, making the implant a predictable treatment foundation for the long-term restoration of missing teeth [29]. Undoubtedly, these are indispensable features for restorations in the aesthetic zone.

Goodacre states that aesthetic failures in implant dentistry are known to outnumber mechanical failures, especially in the anterior dentition [30]. Incorrect placement of implants in this area can lead to aesthetic problems that might be difficult to solve. A poor emergence profile can compromise the patient's oral hygiene, and consequently, the health of soft tissues around the implants can be negatively affected [31].

It is worth remembering that the crown of an endodontically treated tooth may darken over time and it may require a supply of whitening or a dental crown replacement [32]. Therefore, if the natural tooth is surrounded by natural dentition, an implant may produce a more aesthetic result [33]. In implant treatment, the clinical crown can be designed in a shape to precisely reflect the clinical patient's situation; its shape may be similar to the crown of the same group of contralateral teeth. However, the aesthetics of ISC can be affected by complications associated with soft tissue [32].

Soft tissue management is an important aspect of aesthetic management in implant dentistry [34]. Deformation of the dental papilla is the most common complication and cause for concern after implant placement. Reduced papilla height can result in "black triangles" and the poor aesthetic outcome of the restorative treatment. The overall prevalence of papillary contracture after implant placement has been reported to range from 5%–20% when compared with contralateral natural teeth [35]. There is a very important clinical problem especially when two or more adjacent implants are placed in the anterior maxilla. In such a situation a plan of treatment should be considered to include the endodontic treatment at least one tooth, which would reduce alveolar papilla shortening [36].

Periodontal biotype is an important factor when choosing between implant or restoration treatment for a natural tooth. The human tissue biotype is classified as thin, normal, or thick. The thin periodontal biotypes are friable, escalating the risk of recession after crown preparation and periodontal or implant surgery [37].

According to Torabinejad and Goodacre [38] when the periodontal biotype is thin but healthy around a natural tooth, then the preservation of the tooth through endodontic therapy might provide more appropriate soft tissue aesthetics than tooth extraction and replacement with a dental implant does. Also, Christensen considered that if there is a risk of poor aesthetics in the anterior, connected with complications from the soft tissue, the better solution is RCT [39].

In recent years, a growth has been observed in alternative methods of implant treatment after endodontic complications. An example might be the clinical study by Boff et al., which describes the procedure for implantation after the complications of endodontic treatment, and more – after breaking the root of the central incisor. Instead of producing a fixed partial denture or a new crown, after the extraction of the broken root and the immediate implant placement the author used a pre-existing crown which was cut off and prepared as a temporary provisional crown. The procedure used resulted in a satisfactory aesthetic effect that helped to reduce the treatment time and its costs. The benefit to the patient was to minimize the negative psychological effects associated with the loss of anterior teeth [40].

Choosing proper implant treatment depends on the bone level deficit. It should be determined whether the existing conditions provide a stable bone implant placing. If the stability criterion is met, one can perform the procedure as well as simultaneous implant augmentation. If, however, an assessment of the existing bone conditions does not guarantee the stability of the implant, two-stage treatment procedure should be applied. The first step is to supplement the missing bone (augmentation). Only after 3 to 4 months should the second stage be carried out: implant insertion [41].

However, implantological treatment, like every method, carries the risk of complications, especially so that implantation is a surgical method and as such burdened with complications by definition. The data shown in the "Results" section of the present paper ("3.2: C. Complications..." and Table 7) confirm a higher percentage of complications, both early and late, in case of implant treatment as compared to endodontic treatment, despite a higher survival rate. This is related to iatrogenic factors as well as to patients being uncooperative (not following oral hygiene instructions, smoking, etc.). According to Doyle et al., as many as 18% of procedures end with complications. Subsequently, the authors discuss how to manage them. The main points of this discussion are included in the Appendix as though they are im-

portant for the subject matter as a whole they would rather impede the development of this presentation.

### The effectiveness of implant treatment

The effectiveness of implant treatment depends on a number of different factors. In the pre-operative stage, attention should be paid to any potentially negative conditions for the further treatment prognosis. These include insufficient bone levels at the implant site, periodontitis, and failures of earlier implantation. In the intra-operative phase, the key factors include the following unfavourable ones: adverse anatomic conditions, significant bone defects, and the need for augmentation procedures. Implantologists must also take into account the factors that will affect the success of treatment after the completion of an actual implant therapy (post-operative). The low probability of success is to be expected in patients who have problems with wound healing, are exposed to iatrogenic factors, and those who do not give enough attention to oral hygiene [42].

The effectiveness of the implant procedure depends on – and this is a big challenge for an implantologist – being able to foresee patient's expectations, especially when it comes to anterior teeth replacement, taking into account also the bone quality, the height of the gingival crest and biological width.

So far the survival rates for ISC and RCT have been compared, and based on the literature ISC has proved to be a more durable replacement as far as long-term results are concerned, despite producing more numerous complications. Alternative methods of implantations have also been presented, as they appear in the literature selected.

### The decline of RCT effectiveness over time

Striving to implement an optimal treatment option, the authors of the articles try to explain if and why a decline in RCT over time is observed, despite ISC and RCT survival rates being almost identical shortly after the procedures.

Most of the failures in endodontics emerge from the malfunctioning of the root canal treatment. The direct causes of endodontic complications are bacterial agents that cause infections, including those ones within the canals. A frequent mistake made in the treatment is canal overfilling and pushing the filler material beyond the apical foramen. This situation favours the development of bacterial infection inside the root canal or outside it. The result is damage and an inflammatory response in the periapical area [43]. Carefully performed root canal treatment significantly reduces the risk of failure, but is not a guarantee of success. Regardless of the quality of the treatment performed, the fundamental cause of failure remains the same and is associated with the activity of microorganisms. Their total elimination by disinfection is sometimes impossible, due to the unusual anatomy of the apical root canal. Persistent bacteria can lead to the failure of the therapy, even

if the doctor did not make any mistakes. Inner infection of the canal may also have a secondary character, i.e. caused by bacteria that have penetrated into the canal system during or after the endodontic treatment. Much depends on the quality of the filling: if it is airtight, aerobic bacteria trapped in the canal will die; if not – they can survive, multiply and eventually attack. This applies especially to highly pathogenic strains, tolerant to nutrient deficiency and resistant to disinfectants. Also, in the case of teeth with a narrow or curved canal, tight filling, which guarantees complete resistance to infection, can be very difficult [44]. The reason for the failure of endodontic treatment which was carried out properly can also be the so called "leaky" crown, where bacteria from the saliva have penetrated into the crown.

Non-bacterial factors can also turn out to be responsible for endodontic complications. An example is a foreign body. An example of a causative factor regarding resistance to the treatment of chronic periapical inflammation is cholesterol crystals. A reaction to a foreign body may also be caused by external factors, such as certain components of restorative materials. Periapical changes may also encourage certain plant food components which have infiltrated into the periapical tissue [45].

The reasons for many failures in root canal treatment is not the root canal itself but is a result of recurrent caries, a fracture of the root, as well as periodontal disease combined with periapical periodontitis. Fractures are traumatic in nature. Following traumas, teeth, either after canal treatment or untreated, may undergo longitudinal or transverse root fracturing below the bone level, thus making prosthetic reconstruction impossible. Often the fracture of a tooth root on the vestibular side results from a badly fitted prosthetic crown on a post and core in occlusion. Crown and post overload of even 0.1 mm in improper load axis may lead to a fissure in the subgingival area by repeated occlusion trauma. A bigger trauma may lead to a longitudinal root fissure. In both cases prosthetic reconstruction is not possible [46].

Such factors should be considered as an indication for extraction [47]. Frequently, they will require atraumatic methods of extraction by means of periostoms, luxators, piezosurgery and devices such as Benex control. They allow for the removal of the root remains without the loss and destruction of vestibular lamina which is especially vital in the anterior area. Its loss will necessitate the application of an augmentation material or autogenous bone, regardless of the method used. Implantation, either open or closed, is the only solution, depending on the recommendations.

Endodontic complications are frequent, especially during secondary root canal treatment. This is due to the fact that multiple interventions undertaken to reconstruct the tooth undermine its structure and reduce its resistance to damage, causing the above mentioned fractures [48].

Zitzmann et al. distinguished a number of factors that may adversely affect the desired effect of repeated root canal treatment, including an insufficient level of root canal filling, advanced periapical changes, the unusual shape of the canals and the difficulty of filing them properly, and the failure of previous attempts at endodontic treatment [42]. It seems that the disregard for the consequences of these conditions can be a source of failure in secondary root canal treatment procedures which may result in permanent damage to the root, preventing the reconstruction of its supporting function.

## Conclusions

1. The superior long-term survival rates of single tooth implants suggest that this treatment should be given priority in treatment plans for teeth that are intended to be extracted.
2. For patients with periodontally sound teeth that have pulpal or periradicular pathosis, implant and endodontic treatments had superior psychosocial outcomes, primarily with respect to patient self-image, compared to extraction without replacement or with replacement using a fixed partial denture.
3. A significant drop in the RCT survival rate is observed over time, while for implant treatment this decline is lower.
4. There is a big difference in quoted survival rates for RCT treated teeth among authors, while for ISC the difference is small.
5. Initial endodontic treatment has a high long-term survival rate for periodontally sound teeth that have pulpal or periapical pathosis.
6. Equivalent long-term survival rates have been also reported for extraction and replacement of the missing tooth with an implant-supported restoration.
7. Economic methods may be usefully applied to healthcare outcome questions, because they allow the measurement of costs and benefits to individual patients and to society in general.
8. Treatment plans must be based upon the individual patient's situation.
9. Treatment decisions must be based on the scientific study of clinical outcomes, including clinical, psychosocial, and economic measures.
10. Implant treatment is more expensive than RCT, though implants are more durable.
11. A predictable and aesthetic result can only be achieved by adhering to a proven clinical protocol, which is based on experience, precise diagnostic procedures, and meticulous treatment planning [49].
12. Implants are well accepted by patients, but they must give an informed consent and be aware of the likely early and late complications.
13. The decision whether to extract a tooth with an unclear prognosis or to save it is undoubtedly connected with risk. Usually, a practitioner

should seek out interdisciplinary cooperation in this respect.

14. To maintain a critical attitude towards the possible successful and durable therapeutic effect will prevent extreme steps being taken in treatment, likely to bring about future failures.
15. Natural tooth restoration should be considered when aesthetic demands are the most significant factor. The extraction of natural teeth in the aesthetic zone and their subsequent replacement with implants can lead to unaesthetic results.
16. Even small changes in recession or loss of papillary height can be deemed an aesthetic failure.
17. Retention of endodontically treated natural tooth results in the maintenance of the proximal crestal bone and papilla.

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