To Preserve or Extract? A Scoping Review and a Prognostic Decision Tool Using Multispecialty Indicators

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Because implant-supported restorations have become very popular, there is a tendency to extract teeth and replace them with implants. However, the first goal of dentistry should always be the preservation of natural teeth, given the prerequisite that these can be maintained with the application of appropriate treatment modalities. Therefore, individual tooth risk assessment and prognosis are very important for the treatment planning process. Four important factors influencing the dentist's decision on whether to save or extract a compromised tooth have been identified, and an extensive search of the related English-language literature has been performed. Additionally, a hand search in related journals was implemented, and classic textbooks were consulted. Identified articles on patient-related, periodontal, endodontic, and restorative factors were thoroughly analyzed, focusing on diagnosis and tooth prognosis. A total of 52 references were carefully selected and reviewed. Available information was used to develop a color-coded prognostic decision chart with four different factors and up to 14 crucial parameters. All factors and parameters were analyzed in an effort to help the restorative dentist make a prognostic decision. The proposed color-coded prognostic decision chart can be helpful when a treatment plan is made and predictable restorative care is planned. This comprehensive prognostic decision chart can aid dentists in providing clinical care of high quality and in establishing a consensus on available restorative options. It can additionally help to establish appropriate communication with patients and third-party individuals in the restorative care process, effectively manage risk factors, and provide a framework for quality assessment in restorative treatment. *Int J Prosthodont 2025;38:235–246. doi: 10.11607/ijp.9068*

Modern dentistry's main objective is to restore the oral health status of a patient and provide normal masticatory function, speech, comfort, and esthetics. For that purpose, guidelines of care in restorative dentistry were developed in an effort not only to identify but also to define all clinical conditions requiring restorative care.[1] Today, several options exist for preserving or re-establishing oral health status, with reduced treatment times, minimally invasive techniques, and decreased potential error.[2–3] New diagnostic and therapeutic techniques, novel instrumentation, new biomaterials, as well as advances in digital technologies have contributed to that.[4–5]

A successful treatment outcome depends largely on three important parameters: *(a)* the correct diagnosis after identifying the type, extent, distribution, and severity of diseases; *(b)* the right treatment plan, which will not only provide a therapeutic result for the disease but will also address the chief complaints of the patient;[6] and *(c)* the clinical skills, training, and experience of the operators.[7] Obviously, other factors, such as availability of other specialties, laboratory support, and patient-dentist compatibility, may contribute to the outcome too.

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In the past, a significant effort was made to retain teeth that were compromised. More recently, however, there is a tendency to extract teeth and replace them with implants, because the latter have demonstrated very high success rates and are considered a successful treatment modality.[8,9] Although implant therapy has offered a great service to partially and completely edentulous patients, the fact that many teeth that could have been saved are sacrificed and replaced with implants is disappointing. It should be remembered that the first goal of dentistry should always be the preservation of natural teeth, given the prerequisite that these can be maintained by applying appropriate treatment modalities.[10,11] Toward that end, individual tooth risk assessment and prognosis are vital in the treatment plan process. This process is very demanding, requiring deep knowledge not only of one's specialty but also of related disciplines. A few attempts have been made in the literature to assist dentists in predicting the course of individual teeth, because this is a multifactorial and difficult task.[12–14] Additionally, numerous articles have been published in the past trying to classify teeth according to several criteria the authors have set.[15–17] This fact represents an effort to assess the prognosis of a tooth from a periodontic and an endodontic point of view.[18] However, the decision as to whether a tooth should be preserved or extracted does not depend only on periodontal- or endodontic-related factors. Additional patient-related and restorative factors represent confounding variables that need to be thoroughly assessed, and their contribution to the decision-making process should be weighted too.

Therefore, the primary aim of the present study was to review all patient-related, periodontal, endodontic, and restorative factors and parameters associated with the tooth preservation decision-making process and present a comprehensive model that would assist predoctoral students, residents, and restorative dentists for that purpose. By synthesizing available data published in the literature, this model serves as a valuable tool during treatment planning, particularly in the context of planning predictable restorative care for patients in need. Moreover, beyond aiding in the formulation of treatment plans, this comprehensive model has the potential to elevate the quality of clinical care provided by dentists. The model facilitates the establishment of consensus among dental professionals on the best available restorative options for each patient's unique needs and also fosters effective communication, education, and collaboration with patients and other stakeholders involved in the restorative care process. Furthermore, this model plays a pivotal role in managing and mitigating risk factors associated with restorative procedures, thereby enhancing patient safety and treatment outcomes. Finally, it offers a structured framework for ongoing quality assessment and improvement in restorative treatment practices, ensuring that patients receive optimal care throughout their treatment period.

MATERIALS AND METHODS

The present scoping review aimed to investigate how patient-related, periodontal, endodontic, and restorative factors influence the prognosis of abutment teeth. The review followed the Population, Concept, and Context (PCC) framework to provide a structured approach to the research process.

Population

The population of interest comprised patients with abutment teeth undergoing dental treatment. Subgroups within this population were considered, including age, gender, socioeconomic status, and relevant medical or dental conditions.

Concept

The search strategy and data extraction process included several terms in each one of the four identified concepts:

- Patient-related factors: patient expectations, attitude, finances, compliance, oral hygiene, smoking, parafunctional habits, eating disorders, systemic conditions, genetic disorders, mental attitude, drug abuse, and alcohol abuse.
- Periodontal factors: clinical attachment loss, bone loss, tooth loss, tooth extraction, probing depth, bone defect, furcation involvement, residual ridge, tooth mobility, crown-root ratio, root morphology, root proximity, periodontal treatment, periodontal therapy, and periodontal relapse.
- Endodontic factors: endodontic treatment, endodontic retreatment, restoration, prefabricated post, cast post, metal post, fiber post, post space, internal root resorption, external root resorption, crown fracture, root fracture, nonsurgical treatment, surgical treatment, and apicoectomy.
- Restorative factors: carries, decay, tooth structure loss, tooth malposition, tooth wear, tooth attrition, tooth abrasion, preprosthetic orthodontics, vertical overbite, horizontal overjet, maxillomandibular relationships, occlusal plane, alveolar ridge, malpositioned teeth, and gingival margin.

Context

Contextual factors considered included environmental, clinical, and temporal factors that may influence the relationship between the identified concepts and the prognosis of abutment teeth. The context in which the studies were conducted was described to enhance the understanding and applicability of the findings.

This scoping review included randomized clinical trials, prospective studies, retrospective studies, case series, case reports, case controls, cohort studies, and surveys published in English language. It included searches in PubMed, Embase, Science Direct, and Google Scholar conducted until June 30, 2023. Structured searches were performed using specific keywords related to each concept. Additionally, manual searches were conducted in relevant textbooks and high-impact factor peer-reviewed journals. Two authors (R.A., B.A.) independently screened titles and abstracts for relevance, with disagreements resolved through discussion with all authors to ensure consensus (Fig 1).

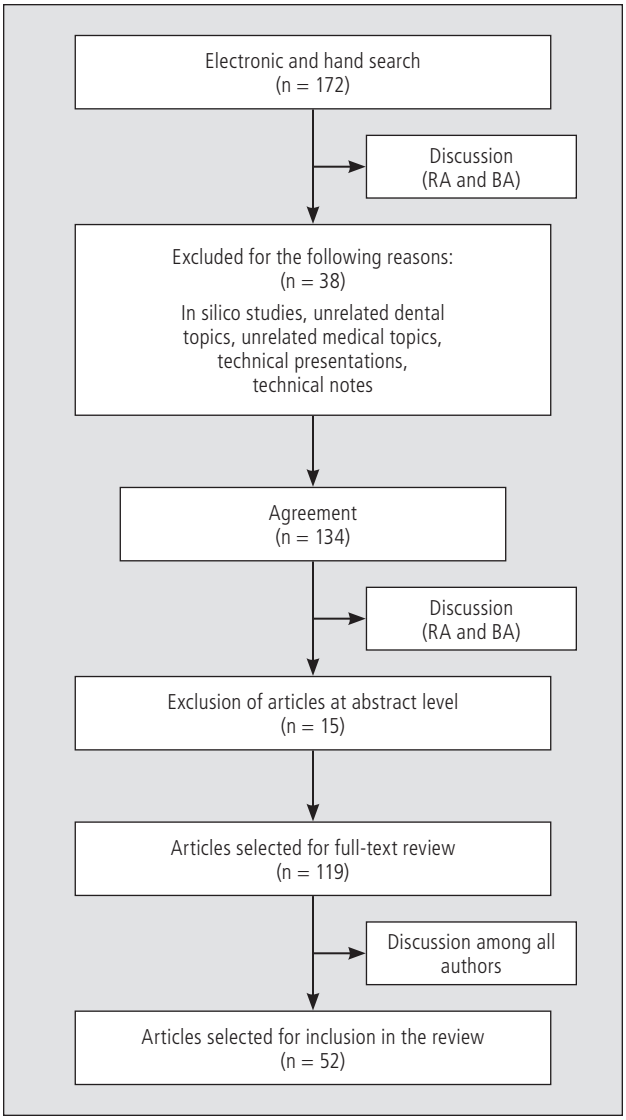

Fig 1 Flowchart of included studies.

RESULTS

From an initial pool of 172 studies, 38 articles were excluded at the title level, while another 15 articles were excluded at an abstract level. After thorough discussion and evaluation, 52 articles were selected for inclusion in this scoping review and classified into categories related to patient factors, periodontal factors, endodontic factors, and restorative factors. Of those articles, 15 were RCTs, 1 was a prospective study, 17 were retrospective studies, 3 were cross-sectional studies, 3 were case series, 2 were surveys, and 11 were case reports.

All factors and parameters that were analyzed from the selected articles were systematically categorized within a color-coded prognostic decision chart, as described in Fig 2, aiming to aid in the prognosis of individual teeth. Teeth that fall into the "green" category on the chart are considered salvageable, while those that fall into the "red" category are nonsalvageable and will need to be extracted. However, those teeth in the "orange" category pose greater challenges and would need careful examination before determining whether they should undergo retention and restoration or extraction.

Patient-Related Factors

Studies with patient related-related factors are listed in Table 1. Expectations, attitude, finances, compliance, oral hygiene, smoking, parafunctional habits, eating disorders, presence of certain uncontrolled systemic and genetic conditions, as well as the use of certain medications are all considered patient-related factors.[24] These factors can be managed to some extent by the dentist to eliminate or reduce their effect on the prognosis of teeth and the provided treatment.

Financial status

Preserving natural dentition and providing the patient with protective or simple direct restorations is less expensive than replacing the teeth with dental implants or fabricating expensive indirect restorations.[24] If the patient requests and insists on extracting a tooth because of financial limitations and the dentist does not see a reason for the extraction, the dentist has the right to refuse that.[20,23]

Mental attitude

According to House,[20] there are four types of patient mental attitudes: *(i)* philosophic, *(ii)* exacting, *(iii)* hysterical, and *(iv)* indifferent. The dentist's attitude and good communication with the patient play an important role in controlling the patient's behavior during treatment and the patient's acceptance of the provided treatment.

Expectations

Restorative dentists should ensure that correct information is easily accessible, communication with patients is clear, questions are answered, empathy and understanding are shown, and feedback is provided.

Patient-related factors			Periodontal factors			Endodontic factors			Restorative factors		
Financial status			Bone loss			Failing endodontic Tx			Extensive caries		
Unlimited		Limited	< 30%	30%–64%	> 65%	1st Tx		> 1st Tx	Cavitated	Deep caries	Root caries
Patient expectations			Probing depth			Type of prosthodontic restoration			Abrasion/erosion		
Reasonable		Non-reasonable	< 5 mm	5–7 mm	> 7 mm	Definitive restoration, fully sealed	Definitive restoration, coronal leakage	No definitive restoration/ absence of coronal seal	Minimally exposed	Distinctly exposed, lost < 2 mm	Extensively exposed, lost ≥ 2 mm/ necrotic pulp
Patient attitude			Clinical attachment loss			Existence of post			Abfraction		
Favorable		Unfavorable	1–2 mm	3–4 mm	> 5 mm	Post length ≥ crown length, post diameter 1/3 of root diameter		Post length < crown length, post diameter < 1/3 diameter	Caries lesions associated with abfraction lesions	Cervical margins located subgingivally	Extensive tooth structure loss with exposed pulp
Carb intake (snack frequency)			Furcation involvement			Complicated Endo Tx			Coronal tooth structure loss		
< 3x		> 3x	I	II	III	Complete healing	Incomplete healing	No healing	With ferrule/ sound periodontium	With ferrule/ periodontally involved	No ferrule effect/ nonvital/ periodontally involved
Oral hygiene			Crown-root ratio			Root resorption (internal/external)			Tooth malposition		
Good (SOHI: 0–1.3)	Fair (SOHI: 1.3–3)	Poor (SOHI: 3.1–6)	2:03	1:01	> 1:1	Absent		Present	Mildly supra-erupted or minimally tipped	Moderately overerupted or severely tipped	Severely overerupted, nonrestored to normal functional contact
Parafunctional habits			Root morphology			Crown fracture			Unfavorable max-mand relation		
Not present		Present	Normal root morphology	Root concavities, cervico-enamel projection	Root concavities or cervico-enamel projection with > 50% bone loss	Uncomplicated		Complicated	Normal articulation with the teeth		Outside normal ridge relation
Smoking			Root proximity (interradicular distance [IRD])			Vertical root fracture			Minimal width/height of alveolar ridge		
Nonsmoker	Former smoker	Current smoker	> 0.8 mm	0.3–0.8 mm	< 0.3 mm	Apical	Middle	Coronal	W: ≥ 6–10 mm H: > 21 mm		W: ≤ 2–4 mm H: < 10 mm
Patient compliance			Previous periodontal Tx or relapse			Apicoectomy					
Compliant		Noncompliant	No relapse		Relapse of PD/abscess	Feasible		Not feasible			
Medication affecting Tx			Mobility								
No effect	Relative	Absolute	I	II	III						
Disease affecting Tx			Bone defect morphology								
No effect	Relative	Absolute	No bone defect	Horizontal/ vertical bone defect	Persistent vertical bone defect after GBR						
Oral congenital/acquired defects											
None		Existing									
Other congenital/acquired defects											
Not affecting		Affecting accessibility									
Salivary flow rate											
≥ 0.1 mL/min		< 0.1 mL/min									
Salivary consistency											
Nonviscous		Viscous									

Tooth can be safely used for prosthetic treatment.
Tooth status should be re-evaluated after phase 1. It can go either green or red.
Tooth cannot be safely used for prosthetic treatment. Extraction is suggested.

Fig 2 Color-coded prognostic decision chart.

Oral hygiene
Patient's oral hygiene, good diet habits, and regular dental check-up visits are denotative of patient cooperation, which has an essential role in the success of the treatment outcomes.

Smoking habits
The presence or absence of smoking habits is also considered part of patient compliance, which is important in preserving natural dentition.

Parafunctional habits
Bruxism could lead to fractures of dental restorations, damage to teeth, headaches, and temporomandibular disorders.[22] It may lead to pain in the masticatory and neck muscles, decreased pain thresholds in the muscles, limited mouth opening, sleep disorders, stress, anxiety, depression, and overall impairment of oral and general health.[19]

Eating disorders
Patients suffering from anorexia nervosa and bulimia nervosa have dental erosion, specifically on the lingual surfaces of teeth, and teeth sensitivity as oral manifestations. Full coverage restorations may help preserve the teeth or help protect them from sensitivity.[19]

Systemic conditions and medications
The conditions that are commonly present in elderly people with clear oral symptoms can be categorized into conditions that affect cognitive or motor function, such as dementia and Parkinson's disease, which both present drug-induced xerostomia and poor oral hygiene. Furthermore, endocrine conditions, such as diabetes, have a significant impact on periodontal health and salivary flow. Many other systemic diseases—such as heart failure, stroke, uncontrolled blood pressure, and end-stage vital organ diseases—require deferral of any elective or complex dental treatment. Many medications may also cause a decrease in salivary flow. These include antidepressants, antipsychotics, alpha-blockers, antihistamines, 5HT1 agonists, opioids, and HIV medications. In these cases, it is important to provide continuous moisture to the oral cavity to prevent caries and candidal infection. Oral ulceration and soft tissue lesions, gingival overgrowth, opportunistic infections, and taste disturbances are also related to using some medications. Therefore, it is essential to conduct a thorough assessment of the overall medical condition of a patient before initiating the clinical evaluation and formulating a treatment plan.[18,19,21,24]

Genetic disorders
Treatment planning is related to the patient's age, the nature and extent of the disorder, and the oral health condition of the patient. Amelogenesis imperfecta (AI), Dentinogenesis imperfecta (DI), familial hypophosphatemic rickets, and Ectodermal dysplasia (ED) are examples of these genetic disorders.

Table 1 Studies Included in Patient-Related Factors

Authors	Year	Study type	General subject
Alves et al[18]	2004	RCT	Medical status
Amorim et al[19]	2014	RCT	Parafunctional habits
House et al[20]	1958	Descriptive study	Patient requests/ expectations
Kikuchi et al[21]	2021	Cross-sectional study	Medical status
Trindade Mde and Rodriguez[22]	2014	RCT	Parafunctional habits
Vujicic et al[23]	2016	Survey	Patient finances
Zafiropoulos et al[24]	2009	Retrospective study	Patient finances

Psychologic disorders
Patients with mental or psychologic disorders are subject to a great number of risk factors for oral and dental manifestations. This has mostly resulted from the side effects of the drugs that they receive, absence of self-care, difficulty in accessing health services, unfavorable attitude toward healthcare providers, and patient's lack of cooperation in dental treatments.

Drug and alcohol abuse
Drug or alcohol abusers may have a high risk of dental caries and periodontal disease from oral neglect. Elective dental care should be postponed until the patient demonstrates an active interest and ability to maintain their dental and oral health before undergoing any substantial dental treatment.[19]

Periodontal Factors
Periodontal disease is one of the most prevalent diseases that can cause irreversible damage to the attachment tissue, leading to tooth loss, which subsequently impacts the patient's quality of life (Table 2).

According to a prognosis system by McGuire and Nunn,[31] it is possible to determine the prognosis of each stage of the disease. Therefore, stage I and II periodontitis would result in a good and fair prognosis, respectively, while stage III has a poor or questionable prognosis and stage IV has a questionable or hopeless prognosis.[31]

Clinical attachment loss
Clinical attachment loss (CAL) is accepted as the gold standard for determining the severity of periodontitis and should be the initial factor used to characterize

Table 2 Studies Included in Periodontal Factors

Authors	Year	Study type	General subject
Becker et al[25]	1984	Retrospective study	Tooth mobility
Cooke and Cox[26]	1979	Case report	Root morphology
Hamp et al[27]	1975	Prospective study	Tooth mobility/ furcation involvement
Cury et al[28]	2003	RCT	Root morphology
Hellden et al[29]	1989	Retrospective study	Furcation involvement
Matuliene et al[30]	2008	Retrospective study	Probing depth
McGuire and Nunn[31]	1996	Case-control study	Periodontal classification
Patel et al[32]	2012	Cross-sectional study	Root proximity
Rasperini et al[33]	2014	Case series	Radiographic bone loss
Saminsky et al[34]	2015	Retrospective study	Periodontal relapse
Seirafi et al[35]	2014	Retrospective study	Periodontal relapse
Shiloah et al[36]	1998	RCT	Clinical attachment loss
Tada et al[37]	2013	Retrospective study	Crown-root ratio

the stage of the disease. If the measured interdental CAL, at the site of greatest loss, is between 1 and 2 mm, the disease is still in stage I; if it is between 3 and 4 mm, it is considered stage II. If the CAL is ≥ 5 mm, it would be characterized as either stage III or IV periodontitis.[36]

Radiographic bone loss

The percentage of bone loss is usually assessed with a periapical radiograph or radiographic bone loss (RBL). It should be used to determine the stage of periodontitis if CAL is not available. Radiographic features of a normal, anatomical intact periodontium should have an average distance of 2 mm from the most coronal portion of the alveolar bone crest to the cementoenamel junction (CEJ).[33] The severity of the disease is characterized as stage III or IV when the RBL is observed extending to or beyond the mid-third of the root.

History of tooth loss

If there's no history of tooth loss due to periodontitis, the stage determination is based on the CAL and RBL measurements. However, if a history of tooth loss due to periodontitis is present, it can modify the disease severity to stage III if there are less than four teeth lost and stage IV if more than five teeth are lost.[33]

Probing depth

If the maximum probing depth detected is ≤ 4 mm, it is categorized as stage I periodontitis, while ≤ than 5 mm promotes the disease to stage II. Stage III and IV periodontitis is when the probing depth found is ≥ 6 mm.[30]

Bone defect morphology

The two types of bone degeneration associated with periodontal disease are horizontal and vertical bone loss. Horizontal bone loss results from bone loss spreading equally along the teeth. A vertical defect is often visible in localized regions, where the alveolar bone loss around teeth/teeth surfaces occurs at varying rates. Severe, localized, narrow intrabony defects can occur because of vertical bone loss. If the bone defects found are mostly horizontal, they are categorized as either stage I or II. If vertical bone loss of ≥ 3 mm is found, it results in either stage III or IV periodontitis.[27]

Furcation involvement

A classification proposed in 1975 by Hamp et al[27] has identified three distinct classes: Class I when a furcation is characterized by < 3 mm of horizontal penetration; Class II, in which there is >3 mm of horizontal penetration but not through and through, and Class III when a through and through horizontal penetration exists. There is an agreement that a Class I furcation problem is treatable and maintainable with the correct care. However, if furcation involvement of Class II or III is found, the periodontitis status is promoted to stage III or IV immediately. The prognosis is poor for teeth with Class III furcation involvement.[29]

Residual ridge defect size

If the ridge defect found is of moderate size (33% to 50% bone loss, extended from the coronal third to the median third), it is categorized as stage III periodontitis. Severe ridge defects (bone loss exceeding 50% from the middle third to the apical third) instantly promote the status to stage IV.[33]

Tooth mobility

Tooth mobility grade I refers to mobility < 1 mm, grade II refers to tooth mobility between 1 and 2 mm, and grade III refers to mobility > 2 mm in a horizontal direction or vertical displacement. Tooth mobility can result from either the loss of periodontal attachment, the application of traumatic forces, or a combination of both. Teeth that display grade III mobility due to periodontal attachment loss are typically recommended for extraction.[25] Moreover, the presence of secondary trauma from occlusion or tooth mobility equal to or greater than grade II is considered stage IV periodontitis. It is considered beneficial to perform occlusal therapy in conjunction with periodontal therapy in the presence of clinical indicators

of occlusal trauma, masticatory dysfunction, or bite collapse to restore the patient's function.[33]

Crown-root ratio

The *crown-to-root ratio* is defined as the proportion between the clinical crown and the root supported by the alveolar bone. It represents the biomechanical concept of a class I lever. It is very often used for evaluating abutment teeth.[37] It measures tooth stability, providing information regarding resistance against leverages of oral forces. The most common cause of poor crown-to-root ratio is periodontitis.

Root morphology

The morphologic factors of teeth, such as root concavities, cervical enamel projections, and enamel pearls, have been considered as plaque retention factors.[28] Root concavities are predisposing factors in the periodontal disease process by providing a site for bacterial plaque accumulation and complicating oral hygiene procedures, because they are generally inaccessible for cleaning. C-shaped roots are also known to increase the difficulty of oral hygiene and the management of periodontitis.[26]

Root proximity

Careful consideration of inadequate embrasure because of root proximity should be considered because it may restrict plaque removal, limit access to instrumentation, and lead to local risk factors for periodontal breakdown.[32]

Previous periodontal treatment and relapse

Periodontal maintenance is a phase of periodontal therapy in which the periodontal condition is monitored, and etiologic factors are reduced or eliminated after the completion of periodontal treatment. This phase of periodontal therapy significantly affects the periodontal prognosis and tooth survival by reducing the recurrence rate and tooth loss.[35] The maintenance intervals are planned for each patient according to their specific risk factors, such as smoking habits, systemic diseases, age, poor oral hygiene, and pocket depth > 6 mm.[35] Research has shown that when patients are treated for periodontal disease but are not enrolled in maintenance programs, they present with a three to five times higher rate of disease progression.

Endodontic Factors

Endodontic treatment aims to preserve the tooth as a functional unit within a functioning dentition (Table 3). The endodontic prognosis of a tooth in isolation from the other categories is primarily linked to the difficulty of the case.[45] Dentists should consider the prognosis of the endodontic, restorative, and periodontal procedures when selecting cases for endodontic therapy.[45]

Table 3 Studies Included in Endodontic Factors

Author(s)	Year	Study type	General subject
Akkayan[38]	2004	RCT	Existence of post
Al-Shammari et al[39]	2006	RCT	Surgical vs nonsurgical endodontic treatment
Aqrabawi[40]	2005	Case report	Surgical vs nonsurgical endodontic treatment
Arrow et al[41]	2021	RCT	Surgical vs nonsurgical endodontic treatment
Barclay[42]	1993	Case report	Initial treatment vs retreatment
Boukpessi et al[43]	2023	Case series	Initial treatment vs retreatment
Caplan and Weintraub[44]	1997	Retrospective study	Success vs failure
Christiansen et al[45]	2009	RCT	Endodontic prognosis
Grahnen[46]	1961	Retrospective study	Initial treatment vs retreatment
Stren and Hirshefeld[47]	1973	Descriptive Study	Existence of post
Gulsahi et al[48]	2007	Case series	Type of restoration/ internal vs external resorption
Hiremath et al[49]	2007	Case report	Initial treatment vs retreatment
Holan and Fuks[50]	1993	Retrospective study	Initial treatment vs retreatment
Kerekes and Tronstad[51]	1979	Retrospective study	Endodontic prognosis/ crown vs root fracture
Molven and Halse[52]	1988	Retrospective study	Initial treatment vs retreatment
Nickenig et al[53]	2008	Retrospective study	Type of restoration
Ng et al[54]	2006	RCT	Existence of post
Özer et al[55]	2011	Case report	Crown vs root fracture
Rosen et al[56]	2014	Retrospective study	Surgical vs nonsurgical endodontic treatment
Strindberg[57]	1956	Retrospective study	Initial treatment vs retreatment
Tada et al[37]	2013	Retrospective study	Crown-root ratio
Tamarut et al[58]	2006	Retrospective study	Initial treatment vs retreatment
Tobón-Arroyave et al[59]	2007	RCT	Initial treatment vs retreatment
Yip et al[60]	2002	Case report	Crown vs root fracture

Initial treatment vs retreatment

The preoperative periapical status appears to be decisive for the outcome of endodontic treatment. Teeth with apical periodontitis have a significantly lower success rate than those without such lesions.[50–52,58,59]

Table 4 Studies Included in Restorative Factors

Author(s)	Year	Study type	General subject
Amorim et al[19]	2014	RCT	Tooth wear
Bánóczy and Nemes[61]	1991	RCT	Extensive caries
Christiansen et al[45]	2009	RCT	Coronal tooth structure loss
Daher et al[62]	2008	Case report	Preprosthetic orthodontics
Erkut et al[63]	2007	Case report	Coronal tooth structure loss
Esposito et al[64]	2018	RCT	Deep caries
Ibarra et al[65]	2001	Case report	Preprosthetic orthodontics
Kerekes and Tronstad[51]	1979	Retrospective study	Tooth wear
Lekholm et al[66]	1999	Prospective study	Alveolar ridge height/ width
Ogihara and Tarnow[67]	2015	RCT	Preprosthetic orthodontics
Ohura et al[68]	2011	Case report	Preprosthetic orthodontics
Tolstunov[69]	2014	Case report	Maxillomandibular relationships

The unfavorable prognosis for endodontic retreatment follows the previously published results of Grahnen,[46] as well as those of Strindberg.[57]

Type of restoration

Endodontically treated teeth are widely considered to be more susceptible to fracture than vital teeth. The survival rate of endodontically treated teeth can be greatly affected by the type of prosthodontic restoration.[53] It has been reported that coronal leakage is often associated with endodontic failure and that a well-constructed coronal restoration has more impact on endodontic success than the quality of the endodontic obturation.[48]

Existence of post

Post placement should only be considered if retention for fixed restorations, either for a single full coverage restoration or abutments for fixed partial dentures (FPDs) or removable partial dentures (RPDs), is inadequate. Clinicians should know that a post does not strengthen an endodontically treated tooth.[54]

Posts with increased length showed both a better distribution and reduction of stress when compared to shorter posts.[38]

Stern and Hirshfeld[47] suggested that the optimal diameter of the post is one-third the diameter of the natural root.

Success vs failure

The most common reason for failure is caries because of poor oral hygiene and microleakage through the restoration. Teeth without a definitive full- or partial-coverage restoration exhibited four times higher incidence of extraction than those with one.[44]

Internal vs external root resorption

Root resorption can be broadly categorized as either external or internal, depending on the resorption site on the root surface.[48] Early detection and a correct differential diagnosis are essential for successfully managing the outcome of internal resorption to prevent the weakening of the remaining root structures and root perforations.[42]

Success depends on the type of resorptive lesion, the lesion's location, and its size.[49] Treatment of root resorption is dependent on the etiology. When resorption is due to pulpal necrosis and periodontal injury, nonsurgical pulp space therapy is performed. Complete chemomechanical preparation is considered an essential step in root canal disinfection. However, the total elimination of bacteria is difficult to accomplish, and the intracanal medicament may help eliminate surviving bacteria between appointments.[43]

Crown vs root fracture

When vertical root fracture (VRF) is diagnosed, the case selection process requires a combination of endodontic, periodontal, prosthetic, and esthetic considerations.[50,51,60] The tooth type, presence of a predisposing periodontal disease, type of coronal restoration, alternatives offered by the modern endodontic treatment approaches, alternatives in case of treatment failure, posttreatment dietary habits, and patient's preferences should all be recognized and incorporated in decision making.[37,55]

Nonsurgical vs surgical endodontic treatment

The treatment alternatives for persistent apical periodontitis include nonsurgical endodontic retreatment, surgical endodontic treatment, or in some instances, tooth extraction.[39,56] The choice to undertake further endodontic procedures for a tooth that has already undergone endodontic treatment with apical periodontitis should be evaluated considering various factors, including the technical feasibility of the procedure, systemic considerations, and the patient's preferences.[39,40] Surgical endodontic treatment may be indicated for teeth with apical periodontitis when nonsurgical retreatment is not possible or when its therapeutic result is questionable.[41]

Restorative Factors

Studies focused on restorative factors are listed in Table 4.

Extensive caries

The clinical diagnosis of a caries lesion should consider location, surface appearance, tactile assessment, and gingival health. The type and scope of intervention depend on the patient's individual risk profile.[61]

Initial to moderate active or inactive carious lesions

These lesions do not generally require tissue removal in the following situations: *(a)* occlusal surface—fissure caries restricted to enamel; *(b)* proximal surface—noncavitated carious lesions limited to the enamel and the outer third of dentin; and *(c)* smooth surface—noncavitated carious lesions limited to the outer third of dentin and micro cavitated lesions.

Moderate to severe inactive carious lesions

These lesions do not require tissue removal in the following situations: *(a)* proximal surface—cavitated lesions in enamel when no tooth or prosthesis contacts the lesion and *(b)* smooth surface—cavitated lesions in enamel and dentin when there is no esthetic implication or prosthesis clasp contacts the lesion.

Moderate to severe active carious lesions

These lesions require minimally invasive tissue removal in the following situations: *(a)* occlusal surface—carious lesions in dentin; *(b)* proximal surface—cavitated lesions in enamel and dentin; and *(c)* smooth surface—cavitated lesions in dentin.[61]

Deep caries

The restorative management of deep caries includes arresting the caries process by promoting a defensive response that will aid in preserving the pulp. Removal of deep carious lesions should follow minimally invasive and gradual principles.

Coronal tooth structure loss

The restorability and prognosis of severely compromised teeth in terms of the decision-making process are determined following the completion of a thorough clinical and radiographic examination. These include the ability to withstand functional loads, the quality of the root canal treatment, the quality and quantity of the remaining coronal tooth structure, the prevention of iatrogenic injuries, and the characteristics of the definitive restoration.[45] For prosthodontic prognosis, the key considerations include *(a)* the remaining sound coronal tooth structure, *(b)* the presence or absence of crown and/or root fractures, *(c)* the need to restore with a full coverage restoration to protect against fracture, *(d)* ability to develop coronal seal, *(e)* ability to obtain ferrule protection, *(f)* ability to establish a protective occlusion, and *(g)* ability to obtain satisfactory esthetics.[45,63]

Tooth malposition

When examining functional considerations of teeth that are over-erupted or severely tipped, sometimes correction of the occlusal plane with enameloplasty, orthodontics, crown lengthening, and/or partial- or full-coverage restorations might offer a solution.[45,63,64]

Tooth wear

Severely worn-down dentition patients present with a reduced lower facial height due to loss of VDO. This can result mainly from parafunctional habits or eating disorders.[19] In certain cases, medication, such as antacids, omeprazole, and ranitidine, can be used to minimize gastric reflux and acid production. Splint therapy is beneficial to prevent the loss of tooth structure from attrition. The use of a full-coverage hard acrylic occlusal splint is recommended for bruxers. In these cases, neutral fluoride gels can also be used as an aid in reducing sensitivity.[51]

Preprosthetic orthodontics

Orthodontic intervention may be needed in cases of multiple missing teeth with diastemas, correction of anterior deep vertical overlap, anterior worn dentition, uprighting of tilted teeth, and orthodontics crown lengthening.[65]

Multiple missing teeth

The selection of the definitive prosthetic treatment, whether an RPD, FPDs, or implant-supported prostheses, is also required at the start of the planning process to correctly plan spaces between the teeth for future pontics or implant-supported restorations.[65]

Vertical overbite

A deep bite can cause trauma to the soft tissues or tooth wear and preclude restoration of missing anterior teeth with removable or fixed restorations.

In cases of overclosure, some situations may require restorative treatment alone, such as an increase of the VDO, or orthodontically by either intrusion of anterior teeth, extrusion of posterior teeth, or a combination of both.

The following approach has been recommended for orthodontic treatment of patients with deep vertical overlap:[68]

- Identification of the correct occlusal plane on a cephalometric radiograph using a fixed landmark.
- Determination of the cause of the deep vertical overbite.
- Evaluation of the gingival margin position.
- Surgical intervention for patients with severe facial disproportion.

Worn anterior teeth

The following orthodontic approaches can be used to restore the anterior dentition: orthodontic intrusion, surgical crown lengthening, and increase of the vertical

dimension through restoring the occlusal surfaces of posterior teeth. With this approach, the space needed for the restoration of the anterior teeth can be gained.[62]

- Uprighting of tilted molars: in patients who require the replacement of a missing tooth adjacent to a tilted molar, the restorative dentist can perform enameloplasty on the tilted tooth, use an attachment or a telescopic crown, or orthodontically upright the tooth.[54]
- Orthodontics extrusion for crown lengthening purposes: ferrule effect, healthy periodontium, and maintenance of restorative margins at the gingival margin or within 0.5 to 1 mm in the gingival sulcus and 3 mm coronal to the bone level are prerequisites for a successful restorative treatment. The orthodontic extrusion has an advantage over surgical crown lengthening in terms of providing a more favorable crown-to-root ratio while also maintaining alveolar bone support of the adjacent teeth and related esthetics.[54,62,67,68]

Unfavorable maxillomandibular relationships

Vertical and horizontal jaw relations are integral components of the mandible's centric relation position and form the starting point of every oral rehabilitation treatment plan. Edentulous patients require a clinical protocol that combines the establishment of the VDO and occlusal plane on mandibular and maxillary wax occlusion rims, followed by a preliminary recorded relationship.[69] The classification of the maxillomandibular relationship in completely edentulous patients characterizes the position of the artificial teeth in relation to the residual ridge and/or to opposing dentition.

Minimal height/width of the alveolar ridge

Trauma, tooth extraction, denture wear, and periodontitis can lead to alveolar ridge defects. It is important to restore the ridge defect by replacing the missing tooth/teeth and achieve good esthetics, phonetics, and masticatory function.[66] Alveolar bone should be initially assessed clinically for a preliminary width and height analysis and interarch-occlusal relationships. In some cases, although 7 to 8 mm of bone width is present, the unfavorable lingual existence of the bone necessitates buccal bone grafting for proper restoratively driven implant placement.

DISCUSSION

Implant-supported restorations exhibit very high survival rates. Several longitudinal studies with follow-up periods of 10 to 20 years have demonstrated that fact.[70] A recent systematic review, which included 10 prospective studies, 9 retrospective studies, and 4 RCTs evaluating 7,711 implants, found cumulative survival rates of 94.6%.[71]

New developments in both materials and therapeutic approaches have contributed to the implant treatment outcomes. The new SAC tool developed by the ITI, categorizing implant dentistry cases as straightforward, advanced, or complex into decision-making processes, can streamline assessments, enhance prognostic accuracy, and ultimately contribute to the longevity of restorative treatment plans. Through the synergistic amalgamation of traditional clinical expertise with cutting-edge technologic advancements, dental professionals can navigate complexities with enhanced efficiency, efficacy, and patient-centeredness, ultimately fostering improved oral health outcomes and patient satisfaction. These facts have led both dentists and patients to adopt an implant-driven approach and not try to save and restore natural teeth, which can be salvaged and function for several years.[72] Working in this direction, the outcomes of the present comprehensive review on patient-related factors, endodontic considerations, periodontal status, and restorative needs serve as critical pillars in treatment planning within contemporary dental practice. By meticulously assessing these multifaceted aspects, clinicians gain invaluable insights into the patient's oral health landscape, facilitating informed decision-making and personalized care pathways. Moreover, recognizing the complexity of decision-making in this context, the authors have highlighted the need for a structured approach, in the form of a color-coded prognostic tool, to assess natural teeth, which can serve as abutments, and guide treatment decisions effectively. The latter is a complex process requiring knowledge of someone's specialty and relevant disciplines. Moreover, the decision of whether a tooth may be retained or not is influenced by establishing the correct diagnosis and selecting the right treatment modality to alter the progression of the disease and ensure restorability. However, this process is sometimes complicated and requires continuous monitoring of the course of the disease in relation to the chosen treatment and the patient's adherence to a maintenance protocol. Therefore, a tooth that was initially retained may be extracted during the re-evaluation period.

All identified factors and parameters were analyzed based on published scientific evidence and categorized in a color-coded prognostic decision chart to assist in the prognosis of individual teeth (see Fig 2). A large number of the identified factors and parameters can be modified and contribute to a successful treatment outcome. However, some factors, which are mainly patient-related, cannot be modified, and they have to be accounted for when a treatment plan is made. The decision of whether a tooth can be retained or not would be easy if all teeth could be categorized in the

red or green boxes of the proposed chart. The teeth that are grouped in the orange boxes are the ones that make the procedure more challenging. Additionally, some of the identified parameters are binary, while others are more complicated to evaluate. Although this process may be relatively easy for experienced specialists, it is not for predoctoral students, residents, and young dentists.

All factors and parameters in the proposed prognostic decision chart should be examined carefully before deciding on whether a tooth should be retained and restored or extracted. This process should be repeated for each tooth after the initial therapeutic measures of phase I and before proceeding to the definitive treatment.

It is recognized that there are limitations in this process, and the use of the proposed comprehensive model can be time-consuming. Nevertheless, it can assist in making the right prognostic decisions and enhance the longevity of a restorative treatment plan.

CONCLUSIONS

One of the most difficult and multifactor-dependent decisions that a restorative dentist must make during treatment planning is whether to keep a restored, endodontically, or periodontally compromised tooth or to extract and replace it prosthetically. Different factors associated with a compromised tooth may play a role in this complex process. This study reviewed all significant factors and provided evidence-based background as to how these criteria in making the decision to save or extract a tooth can be used. These factors are patient-related, periodontic, endodontic, and restorative. All factors should be evaluated by the restorative dentist, whether they are modifiable or nonmodifiable, because both influence decision-making during treatment planning and prognosis. There are no universal rules that can be applied to every case. The restorative dentist should be aware of possible ways to reduce or eliminate the adverse effects of these factors, especially if they result from controllable factors. The clinical criteria, along with data from long-term clinical studies, are still the most important tools available to be used as a guide in deciding whether to extract or retain a tooth.

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