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A Review of Endodontic Considerations in Implant-Supported Prostheses

Abstract

Objectives: To synthesise the contemporary evidence on the role of endodontic disease and treatment in the planning and delivery of implant-supported prostheses, and to derive a rational, patient-centred framework for the retain-versus-replace decision and for the prevention of endodontically related peri-implant complications.

Methods: A structured search of PubMed/MEDLINE, the Cochrane Library and Web of Science was performed for English-language systematic reviews, meta-analyses, consensus statements and longitudinal studies, supplemented by hand-searching of reference lists. Evidence was appraised narratively across four domains: comparative treatment outcomes, restorability, the endodontic status of the implant recipient site, and the endodontic status of teeth adjacent to the planned implant.

Results: Implant-supported single crowns and root canal-treated, restored teeth demonstrate comparably high long-term survival, but the endpoints are not equivalent; implants incur more biological and technical complications and additional interventions over time, whereas extraction is irreversible. Restorability — in particular an adequate ferrule, sufficient remaining coronal dentine and the absence of vertical root fracture — is decisive when a tooth is questionable. Periapical pathology at the recipient site does not preclude implant placement when thorough debridement, primary stability and adjunctive antibiotics are ensured; however, endodontic infection of adjacent teeth is a principal cause of retrograde peri-implantitis, mitigated by adequate implant-tooth spacing, prior endodontic treatment of pathological neighbours and a healing interval before placement.

Conclusions: The endodontic health of the tooth, the recipient site and the adjacent teeth is integral to implant success. A biologically conservative "save the restorable tooth first" philosophy remains defensible wherever the endodontic and restorative prognosis is favourable, with the implant reserved for the truly unrestorable tooth.

Clinical Relevance: Structured endodontic assessment and interdisciplinary treatment planning reduce peri-implant biological complications and support evidence-based decisions on whether to retain a tooth endodontically or to replace it with an implant-supported prosthesis.

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INTRODUCTION

The predictability of osseointegration transformed the management of tooth loss, and the endosseous implant is now a mainstream option for replacing a missing tooth.[1,2] Longitudinal data confirm high survival for implant-supported single crowns and fixed dental prostheses, with figures commonly exceeding ninety-five per cent at five years.[3,4] This success has, however, reshaped clinical decision-making at the interface between endodontics and prosthodontics. The pivotal question is now frequently framed as whether a structurally or endodontically compromised tooth should be retained through root canal treatment and restoration, or extracted and replaced with an implant-supported restoration.[5,6,7] The framing is deceptively simple, because the "survival" of an implant and the "survival" of a root-filled tooth are not equivalent endpoints, and the choice carries biological, functional, economic and psychosocial consequences that extend well beyond the individual tooth.[8]

Although the two disciplines are conceptually distinct, endodontic disease and its sequelae remain central to implant therapy in several respects. First, the pulpal and periapical status of the tooth to be replaced determines whether extraction is genuinely warranted. Second, the endodontic condition of the recipient site and of the neighbouring teeth influences the timing of placement and the risk of early biological complications, including a distinct entity termed retrograde (apical) peri-implantitis. Third, natural teeth that support or abut implant-retained fixed prostheses may themselves develop pulpal pathology whose diagnosis is complicated by the restoration. The purpose of this narrative review is to consolidate the current evidence relating endodontics to implant-supported prosthodontics and to translate it into a defensible framework for treatment planning.

METHODS

This narrative review was based on a structured search of the English-language literature indexed in PubMed/MEDLINE, the Cochrane Library and Web of Science up to 2024, using combinations of the terms "endodontic," "root canal treatment," "dental implant," "implant-supported prosthesis," "retrograde peri-implantitis," "implant periapical lesion," "periapical pathology," "immediate implant," "restorability" and "treatment planning." Reference lists of retrieved articles and relevant textbooks were hand-searched to identify additional sources. Priority was given to systematic reviews, meta-analyses, consensus and position statements, and longitudinal cohort studies; case reports and case series were included where they illustrated uncommon but clinically important phenomena such as retrograde peri-implantitis. As this is a narrative rather than a systematic review, no formal risk-of-bias appraisal or meta-analytic pooling was undertaken, and the synthesis is necessarily interpretive.

RESULTS AND DISCUSSION

The natural tooth and the osseointegrated implant: a biological contrast

The rational comparison of endodontic and implant therapy begins with the recognition that the two structures are biologically dissimilar. The natural tooth is suspended within the alveolus by a periodontal ligament that provides proprioception, physiological mobility, shock absorption and a capacity for repair, and it retains a vital or treated pulp space that participates in the host response.[9,10] The osseointegrated implant, by contrast, is in direct ankylotic contact with bone, lacks a periodontal ligament and proprioceptive apparatus, and presents a transmucosal interface that is more vulnerable to plaque-associated inflammation.[11] These differences have direct clinical consequences. Apical periodontitis is a biofilm-mediated disease of the root canal system that resolves predictably once the intracanal infection is controlled, whereas peri-implant disease, once established, is comparatively difficult to arrest.[11,12]

Peri-implant mucositis and peri-implantitis are now formally defined inflammatory conditions, and epidemiological syntheses report a substantial prevalence of peri-implantitis at the patient and implant level.[12,13,14] Biological implant failure is multifactorial, with infection, host susceptibility, smoking and loading factors all implicated.[15] Because the success criteria for the two modalities differ — an implant with marginal bone loss that remains functional is not necessarily classified as a failure, whereas a root-filled tooth is judged against radiographic periapical healing and functional retention — direct numerical comparison of "success" is intrinsically problematic.[5]

The core clinical dilemma: retain endodontically or extract and implant

The most influential body of evidence on this question consists of systematic reviews commissioned to compare the outcomes of root canal treatment and restoration against extraction and replacement.[5,6] In their landmark systematic review, Torabinejad and colleagues concluded that the long-term survival of endodontically treated, restored teeth and of implant-supported single crowns was comparable and superior to that of fixed partial dentures, and that extraction without replacement was associated with inferior psychosocial outcomes; however, the authors emphasised that the available evidence permitted only tentative, largely indirect comparisons.[5] Iqbal and Kim similarly found no clear superiority of one modality over the other, but observed that implant restorations were more likely to require subsequent intervention.[6]

Subsequent longitudinal and retrospective comparisons reinforced this nuance. Doyle and co-workers reported similar failure rates but a higher incidence of post-treatment intervention among single-tooth implants than among initial non-surgical endodontic cases.[24] Hannahan and Eleazer found equivalent success for implants and endodontically treated teeth, while implants required more post-operative treatments and longer times to function.[25] A pooled analysis by Setzer and Kim confirmed comparable long-term survival for the two modalities.[7] Salinas and Eckert, addressing single-tooth replacement specifically, likewise reported high survival for implant restorations but noted the heterogeneity of the underlying studies.[23] More recent cohort data have identified shared and distinct prognostic factors for the

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two treatments.[27] Torabinejad and colleagues later extended the comparison to endodontic microsurgery versus single implants, again finding comparable outcomes and reaffirming the value of tooth retention where feasible.[26,28]

These findings should be interpreted against the strong evidence base for endodontic outcomes in isolation. Systematic reviews of primary root canal treatment report periapical healing in the region of seventy-five to eighty-five per cent under strict criteria, and tooth survival exceeding ninety per cent over the medium term.[16,17,18] Large epidemiological datasets, including a cohort of more than one million teeth, corroborate survival of the order of ninety-seven per cent at several years, with the small proportion of failures generally presenting early.[19,20,21,22] The practical implication is not that one modality is universally preferable, but that survival endpoints are broadly equivalent while the endpoints themselves are asymmetric: extraction is irreversible and sacrifices the periodontal ligament, whereas an implant complication frequently entails more complex and costly remediation.[29]

Restorability and prognostic determinants of the retain-versus-replace decision

Where survival data are broadly comparable, the decision is more usefully driven by tooth-specific prognostic factors than by modality alone. The single most important determinant is restorability. The quality of the definitive coronal restoration is at least as influential as the quality of the root filling in predicting the survival of an endodontically treated tooth, and teeth that receive timely cuspal coverage survive substantially longer.[30,31] A ferrule of one and a half to two millimetres of sound circumferential dentine markedly improves fracture resistance, and its absence compromises the survival of both the restoration and the underlying root.[32,33,34]

Conversely, several endodontic and structural findings shift the balance decisively toward extraction and implant placement. Vertical root fracture, extensive subcrestal loss of tooth structure that precludes an adequate ferrule or biologic width, unfavourable crown-root ratio, non-negotiable perforations, and severe resorptive or anatomical complications all reduce the predictability of tooth retention.[35] Strategic value within the overall treatment plan, periodontal support, caries risk, and the patient's wishes and ability to maintain the tooth complete the assessment.[8] A questionable tooth with a favourable endodontic and restorative prognosis should generally be treated and retained; a tooth that is truly unrestorable is appropriately replaced.[8,29]

Endodontic status of the implant recipient site: placement into sites with periapical pathology

When extraction is unavoidable, the endodontic and infective status of the socket becomes a planning variable. Residual periapical granulomas, cysts, retained root fragments and persistent biofilm at a previously infected site have all been implicated in early peri-implant complications, and were historically considered contraindications to immediate placement.[36] The contemporary evidence is more permissive. A systematic review by Waasdorp and colleagues concluded that implants can be placed into sites affected by periapical and periodontal infection when thorough debridement and systemic antibiotics are employed.[45] Pre-clinical work demonstrated high survival for immediate implants placed into infected sites, although bone-to-implant contact could be impaired.[46]

Clinical series and syntheses have largely supported this position. Crespi and colleagues reported favourable integration of fresh-socket implants placed into periapically infected sites, and a large retrospective analysis of immediately placed implants in sites exhibiting periapical pathology found survival comparable to that in non-infected sites.[47,48] Retrospective and systematic evaluations of immediate placement into sites with periapical lesions, and meta-analyses comparing infected with non-infected sockets, have consistently reported similar survival, marginal bone change and soft-tissue outcomes, provided that meticulous curettage, primary stability and antimicrobial cover are achieved.[49,50,51] Reviews addressing post-extraction placement in endodontically infected sites frame this as a legitimate alternative to protracted endodontic retreatment in selected cases.[52,53] The prevailing recommendation is therefore that periapical pathology at the recipient site does not, of itself, contraindicate implant placement, but mandates complete removal of pathological tissue, confirmation of primary stability, and appropriate systemic antibiotic support; a staged approach remains prudent when acute infection, extensive bone loss or inadequate stability is encountered.

Endodontic status of adjacent teeth: retrograde (apical) peri-implantitis

Retrograde peri-implantitis — also termed apical peri-implantitis or the implant periapical lesion — is a clinically distinct entity in which a periapical radiolucency develops around the apical portion of an implant while the coronal bone-to-implant interface remains osseointegrated.[36,37,38] It typically presents within the first months after placement, often with pain, a mucosal sinus tract or apical swelling, and an apical radiolucency around the implant.38 From the standpoint of this review it is the most important endodontically driven complication of implant therapy, because its principal aetiology is the spread of infection from the endodontic pathology of teeth immediately adjacent to the implant, or from residual infection at the recipient site itself.[38,39]

Several mechanisms have been proposed: pre-existing apical periodontitis or failed root canal treatment on a neighbouring tooth; residual periapical lesions, cysts or root remnants at the implant site; bacterial contamination during placement; and thermal injury from over-heating during osteotomy preparation.[38,39,40] Experimental and clinical observations indicate that endodontic infection of a tooth adjacent to an osseointegrated implant can precipitate a periapical lesion around that implant, and microbiological analyses of affected implants have recovered species characteristic of endodontic infection.[39,41] Reported occurrence varies widely across case series and retrospective cohorts, and higher rates are consistently associated with periapical lesions at the

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extraction site or on adjacent teeth, periodontal disease at the site, and a short implant-to-tooth distance.[41,43]

Prevention is largely a matter of endodontic vigilance during implant planning. It is prudent to evaluate the pulpal and periapical status of every tooth adjacent to a proposed implant site, to complete endodontic treatment of any pathological neighbour before placement, to allow an appropriate healing interval after such treatment, and to maintain a minimum of approximately two millimetres between the implant surface and the adjacent root.[41,43] When retrograde peri-implantitis does occur, management is guided by the vitality and endodontic status of the adjacent tooth and by the severity of the implant lesion: options range from non-surgical treatment with antibiotics and endodontic therapy of the culpable adjacent tooth, through surgical debridement, apical resection of the implant and guided bone regeneration, to explantation in refractory cases.[40,42,43,44] Decision trees derived from the collated literature emphasise early diagnosis and resolution of the endodontic source as prerequisites for implant retention.[43,44]

Endodontic considerations around existing implant-supported prostheses

Endodontic disease also intersects with implant prosthodontics after the restoration is in service. Natural teeth that abut or are splinted to implant-retained fixed prostheses remain susceptible to caries and pulpal pathology, and the presence of the restoration can both mask and complicate diagnosis. Pain in the region of an implant-supported prosthesis has a broad differential that includes peri-implant inflammation, occlusal overload, screw or component complications, and — importantly — pulpal or periapical pathology of an adjacent natural tooth, as well as non-odontogenic and neuropathic sources.[57,58] Because implants are not innervated by a pulpal proprioceptive apparatus, symptoms may localise poorly, and persistent dentoalveolar pain after apparently successful root canal treatment further complicates the picture.[57]

Careful application of standardised diagnostic terminology, pulp sensibility testing of adjacent natural teeth, and selective imaging are therefore essential before attributing peri-implant symptoms to the implant itself.[58] Where an abutment or adjacent tooth requires root canal treatment, access through an existing fixed prosthesis is technically demanding and may compromise the restoration; the restorative consequences must be weighed at the planning stage. An undiagnosed endodontic lesion on a tooth neighbouring an implant can, moreover, undermine the peri-implant bone and jeopardise the prosthesis, reinforcing the need to resolve endodontic disease in the vicinity of implants promptly.[39,41]

Imaging and diagnostics at the endodontic-implant interface

Two-dimensional periapical radiography remains the first-line investigation but is limited in distinguishing endodontic from peri-implant pathology and in assessing three-dimensional bone architecture. Cone-beam computed tomography (CBCT) provides valuable adjunctive information in selected endodontic situations — including the assessment of complex periapical lesions, resorption and the relationship of lesions to adjacent structures — and is widely used in implant site planning.[54,55,56] Position statements from endodontic and radiology bodies advocate a justified, case-specific use of CBCT that balances diagnostic yield against radiation dose, restricting its use to situations in which conventional imaging is insufficient.[54,55] At the endodontic-implant interface, judicious CBCT can help to differentiate a retrograde peri-implant lesion from apical periodontitis of an adjacent tooth, to identify residual pathology at a prospective recipient site, and to plan implant position relative to adjacent roots.[56]

Tooth-preservation alternatives before defaulting to an implant

Given the comparable survival of retained teeth and implants, the contemporary endodontic armamentarium offers several avenues for tooth preservation that should be considered before extraction. Non-surgical retreatment is effective for many endodontic failures, and systematic comparison indicates that retreatment and surgical endodontics offer complementary rather than competing pathways to healing.[62] Contemporary endodontic microsurgery, employing magnification, microinstruments and biocompatible root-end materials, achieves markedly higher success than traditional root-end surgery, with pooled healing rates that rival those of alternative treatments.[59,60,61] For appropriate teeth, intentional replantation has re-emerged as a predictable procedure with favourable retention outcomes, and autotransplantation offers a biological replacement option in selected younger patients.[63,64,65]

Upstream of these, strategies that avoid pulpal necrosis altogether — vital pulp therapy for the exposed but treatable pulp, and regenerative endodontic procedures for the immature tooth — further expand the scope for retaining natural dentition and its periodontal ligament.[66,67] Where initial root canal treatment has been unsuccessful, a structured appraisal of endodontic alternatives is warranted before an implant is selected by default.[29] The clinical principle that emerges is one of biological economy: the periodontal ligament, once lost to extraction, cannot be restored, and its preservation confers proprioceptive, adaptive and site-preserving benefits that an implant cannot replicate.

Decision-making, patient-centred and economic considerations

Rational integration of these factors requires a structured, tooth-specific decision framework rather than a modality preference. Such frameworks weigh the endodontic prognosis, restorability, periodontal support, strategic and aesthetic value, and patient factors to guide whether to treat, extract or replace a questionable tooth.[8] Economic analyses generally favour tooth retention: modelling of root canal treatment against implant replacement, and of endodontic retreatment against fixed partial denture and single-implant alternatives, indicates that retaining the natural tooth is frequently the more cost-effective option over relevant time horizons.[68,69] Patient-reported outcomes and preferences, the reversibility of each pathway, and the maintenance burden of each option are integral to shared decision-

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making. Interdisciplinary communication between the endodontist, the implant surgeon and the restorative dentist is repeatedly identified as the key determinant of long-term success where endodontic pathology is present in the vicinity of a planned or existing implant.[41,70]

LIMITATIONS AND FUTURE DIRECTIONS

The evidence underpinning this review has important limitations. Much of the comparative literature relies on indirect comparisons, heterogeneous success criteria and retrospective designs, and randomised trials directly comparing endodontic retention with implant replacement are scarce and ethically challenging. The reporting of retrograde peri-implantitis is dominated by case reports and small retrospective series, so estimates of its incidence and the efficacy of individual interventions remain uncertain, and classification systems continue to evolve. Standardisation of outcome measures including patient-reported outcomes, harmonised definitions of implant and tooth "success," and consistent reporting of endodontic status at the recipient and adjacent sites would substantially strengthen future syntheses. Prospective, adequately powered studies that record the pulpal and periapical condition of neighbouring teeth as explicit covariates of implant outcome are a clear priority.

CONCLUSIONS

Within the limitations of the available evidence, several conclusions can be drawn. First, root canal-treated, restored teeth and implant-supported single crowns achieve comparably high long-term survival, but the endpoints are not interchangeable, and extraction remains an irreversible sacrifice of the periodontal ligament.[5,7] Second, restorability governed chiefly by ferrule, remaining coronal dentine and the absence of vertical root fracture is the decisive discriminator for the questionable tooth, and should guide the retain-versus-replace decision more than modality preference. Third, periapical pathology at the recipient site does not contraindicate implant placement when thorough debridement, primary stability and antibiotic cover are secured. Fourth, the endodontic condition of teeth adjacent to a planned implant is a genuine risk factor for early biological failure through retrograde peri-implantitis, and is best managed by pre-emptive endodontic treatment of pathological neighbours, adequate implant-tooth spacing and a healing interval before placement. A biologically conservative philosophy retaining the restorable tooth wherever the endodontic and restorative prognosis is favourable, and reserving the implant for the genuinely unrestorable tooth remains well supported, and is best delivered through close interdisciplinary collaboration.

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