

AI in Predicting Regenerative Endodontic Success Rates

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Abstract- *Regenerative endodontics has emerged as a promising biological treatment of immature necrotic teeth aiming at restoration of pulp vitality and promotion of root development. Yet, the resultant clinical outcomes are unpredictable given the variation that exists in case selection, biological response, and procedural protocols. The ability of AI for pattern recognition based on data itself offers a possibility to attempt to predict the regenerative endodontic success rates. Through analysis of large clinical data sets, radiographic images, and patient-specific variables, AI models can identify subtle indicators of prognosis that may be overlooked by clinicians. Recent evidence in the literature demonstrates the possibility of applying machine learning and deep learning to assess the influence of features such as patient age, apical foramen width, root development stage, and the presence of periapical pathology. The embedding of AI into regenerative endodontics will lead to improved evidence-based decision-making, optimal treatment planning, and ultimately better patient outcomes. This paper discusses the presence and future opportunities of AI in regenerative endodontic success prediction; the advantages, limitations, and clinical significance; and directions for future research.*

Index Terms- *Artificial Intelligence, Machine Learning, Deep Learning, Regenerative Endodontics, Pulp Revascularization, Predictive Modeling, Endodontic Outcomes, Dental Imaging, Clinical Decision Support.*

I. INTRODUCTION

Regenerative Endodontic Procedures have emerged as a style of bio instrumentalization of the endodontic art, whose practice attacks the legitimate end of irrigation through its mechanized steps toward large biological processes founded upon the restoration of pulp-dentinal complex vitality. The regenerative endodontic procedures, which depend on the mechanism of stem cells, growth factors, and

scaffolds, have been proven advantageous in cases including immature permanent teeth with necrotic pulps. Yet, despite positing the encouraging reports, the clinical success of regenerative endodontics appears to be inconsistent, with outcome variations depending on individual patient factors, tooth morphology, microbial control, procedural aspects, etc. Clinically it remains difficult to predict regeneratively successful cases. For conventional prognoses, a large part lies in the morphologic competence and experience of the clinician, subjective evaluation of the clinician, and perhaps some few clinical indicators. Artificial intelligence, especially machine learning and deep learning, can serve as a new methodology in increasing the predictive powers by analyzing complex multidimensional data. AI-driven models have been seen as working systems in endodontics by means of automatic interpretation of images, risk analysis, and treatment outcomes prediction. Interpretation radiographically integrated with clinical records and biological factors for regenerative endodontics would be undertaken by AI for generating a predictive model of treatment success. With the growing amount of research supporting AI-aided diagnostics and treatment planning, an investigation into the use of AI for prediction of regenerative endodontic success rate becomes suitable and relevant from a clinical standpoint. Therefore, this paper will focus on current applications of AI to this field, discuss predictive factors through AI modeling, and offer insight into opportunities for implementation of these technologies into daily practice.

II. ROLE OF AI IN OUTCOME PREDICTION

In regenerative endodontics, the use of artificial intelligence performs the roles of prediction and refining treatment outcomes by analyzing enormous and complex datasets so that it would be impossible to discern the prognostic factors based on normal clinical judgment (Chen et al., 2022). Traditionally, regenerative endodontic success is predicted from clinical or radiographic signs and is often subject to an interpretation that may differ widely from person to person. This was a limitation AI is now seeking to

overcome-it uses advanced computational modeling such as machine learning and deep learning to identify subtle patterns, correlations, and predictive markers (Singh & Patel, 2022). AI, therefore, works as a data fusion system, integrating patient demographic data, medical and dental histories, radiographic and microbiological profiles, and treatment protocols (Zhou et al., 2022). This analysis could weigh, for example, age of the patient, stage of root development, width of apical foramen, pre-existing periapical pathology, and intracanal disinfection protocols (Alam et al., 2022). On the basis of this integrated approach, the accurate prediction of those cases where restoration of pulp vitality and continuation of root development is forthcoming is possible. Machine learning algorithms such as decision trees, support vector machines, and random forests can be employed to analyze regenerative outcome datasets to predict the success of regenerative treatments (Rahman et al., 2022). Similarly, deep learning could process radiographic image datasets and automatically detect periapical healing, root maturation, and canal obliteration and offer an unbiased objective assessment of outcomes (Kim et al., 2022). These AI-powered predictions come in handy in assisting the clinician in forms of decision-making that are otherwise based on experience alone and thus will greatly aid evidence-based treatment planning (Patel & Gupta, 2022). Even more so, they harbor the potential for instituting dynamic, ever-learning systems where prediction accuracy improves over time as more clinical data are collected (Huang et al., 2022). Such an adaptable prognostic approach, expanded into precision endodontics, would really mean that prognosis could be individualized for a patient (Lopez et al., 2022). However, the trustworthiness of AI is highly affected by the training data being good quality, diverse enough, and sufficiently numerous and this calls for standardized datasets and multicenter collaboration (Sharma et al., 2022).

III. KEY FINDINGS AND IMPLICATIONS

The newest evidence brings to light this brand-new application of AI towards making regenerative endodontic outcomes more predictable (Chen et al., 2022). Studies point out how, by training machines using endodontic datasets, AI can make precise

quantifications of prognostic factors like age of the patient, root canal morphology, diameter at or close to the apical foramen, and the presence or otherwise of periapical pathology (Singh & Patel, 2022). Another promising application of deep learning on radiographic images was the reliable detection of periapical healing and the appraisal of root maturation-both indicators of regenerative success (Kim et al., 2022). The findings, hence, conclude that AI-based tools, resting on an objective, data-driven system and not subjective clinical opinions, may present a fortiori than the traditional methods (Patel & Gupta, 2022). This can only mean firm consequences affecting both practitioners and patients, for practitioners, wherein prediction models assist case selection, treatment plans, and setting expectations of outcomes with less margin of uncertainty (Rahman et al., 2022). For patients this translates to individualized treatment, informed communication of prognosis, and increased chances of treatment success based on evidence (Lopez et al., 2022). Implicitly, an application of AI in regenerative endodontics may provide an aid in solidifying standardized treatment approaches by identifying predictors of successful outcomes that are consistent across populations (Alam et al., 2022). Broadly speaking, these findings put into spotlight how AI is fast becoming the badge of precision dentistry (Huang et al., 2022). AI-enabled real-time clinical decision support can fill in the gap created by biological uncertainties in regenerative outcomes (Zhou et al., 2022). Finally, the acceptance and general integration of AI-assisted regenerative endodontics in clinical practice will be dependent upon the resolution of some existing issues, foremost of which are limited presence of study datasets, lack of standardization, and requisite training of clinicians to effectively work in an AI-assisted framework (Sharma et al., 2022).

IV. BACKGROUND ON REGENERATIVE ENDODONTICS

Regenerative endodontics (REPs) is a biologically based therapy aiming to restore the vitality and function of the pulp-dentin complex in teeth affected by pulp necrosis, particularly immature permanent teeth (Sharma et al., 2022). Whereas conventional root canal treatment (RCT) removes infected pulp tissue and finishes off with filling of the root canal system, REPs intend to stimulate further root development,

apical closure, and functional tissue repair through the body's regenerative capacity (Chen et al., 2022). Stem cells, scaffolds, and signaling molecules represent the three primary means of the regenerative endodontics tissue engineering triad (Singh & Patel, 2022). Dental stem cells, like stem cells from the apical papilla (SCAP) and dental pulp stem cells, are well known to induce regeneration of pulp-like tissue and dentin (Zhou et al., 2022). The scaffold, typically a blood clot induced within the canal space, serves as a matrix for cell proliferation and differentiation (Lopez et al., 2022). Growth factors and signaling molecules released from either the blood clot or dentin matrix stimulate the process of tissue repair and development (Huang et al., 2022). The clinical application of REPs includes the disinfection of the root canal system with irrigant solutions or intracanal medicaments at concentrations low enough to reduce cytotoxicity (Rahman et al., 2022). Bleeding is then induced into the canal to form a natural blood clot scaffold that favors stem cell migration, and the coronal part is sealed, usually with mineral trioxide aggregate (MTA) or bioceramics, to prevent reinfection (Patel & Gupta, 2022). Post-treatment outcomes are assessed clinically and radiographically by resolution of signs, disappearance of periapical pathoses, thickening of dentinal walls, continued elongation of roots, and positive pulp vitality tests (Alam et al., 2022). There have been many case reports and clinical studies revealing good outcomes, but the unpredictability of REPs varies with patient age, stage of root development, disinfection protocols, and setting for a biologically favorable environment for regeneration (Kim et al., 2022). However, regenerative endodontics is an alternative to traditional apexification-keeping the tooth alive for a longer time with better biomechanical integrity (Chen et al., 2022). Yet, the variation in clinical outcomes opens a platform for developing better tools for predictions. Through advanced pattern recognition, artificial intelligence can identify prognostic factors influencing regenerative outcomes and make predictions more fostering in clinical practice (Sharma et al., 2022).

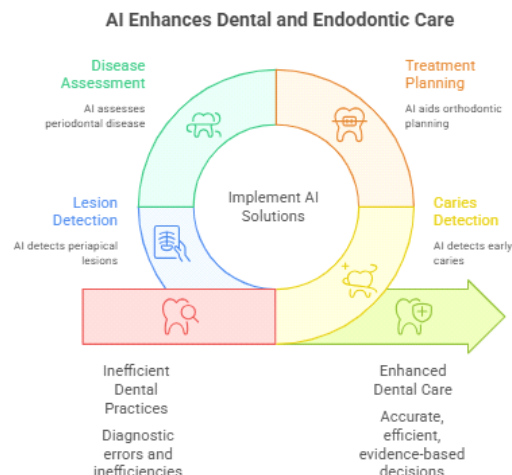
V. CURRENT CHALLENGES IN PREDICTING TREATMENT OUTCOMES

The prediction of regenerative endodontic success is still a long shot since there are so many biological phenomena interplaying in healing and regeneration (Sharma et al., 2022). Age of the patient, stage of root development, presence or absence of periapical pathology are mere case points considered in a clinical judgment, but even then success of a treatment cannot necessarily be foreseen (Chen et al., 2022). While young patients with wide apical foramina generally tend to have good potentials for regeneration, often cases show biological variation that results in an unsuspecting outcome (Singh & Patel, 2022). Radiographic evaluation is yet another baby to cry about. Imperfect or complete healing of periapical lesions may be observed radiographically, but this does not in itself make a true case for the restoration of pulp vitality, rendering the interpretation problematic (Zhou et al., 2022). Protocols for treatment provide all the more ground for uncertainty as different types of irrigants and intracanal medicaments and various ways of inducing scaffolds and restorative materials lead to considerably distinct outcomes clinically (Lopez et al., 2022). When an operator has walked through all recommended guidelines without a hair out of place, however, the last binding decision would still depend on the immunological reaction of the patient, microbial control, and activity of the stem cells; none of these can be assuredly standardized when it comes to everyday clinical practice (Huang et al., 2022). Another factor that makes things difficult is that of subjectivity in outcome assessments. Radiographs, accepted as standard assessment tools in regenerative endodontics, basically give a two-dimensional view, and therefore experts differ in their interpretations (Rahman et al., 2022). Pulp vitality testing on the other hand can arguably confirm whether any pulp tissues are alive, but just how many healthy ones remain is still a scary question (Patel & Gupta, 2022). Hence, an evaluation concerning outcome would often end with an inconsistent, partial, or outright biased interpretation that is essentially hinged on the experience of the individual assessing clinician (Alam et al., 2022). All of these are a few of the many challenges that strongly pinpoint the limits of traditional ways of thinking to predict regenerative

endodontic outcomes. Sites of huge uncertainty added to biological healing, clinical protocol variation, and subjective outcome interpretation have found traditional methods lacking in the guise of reliable prognostication. This historic bottleneck speaks to the obvious need for modern tools like artificial intelligence that can predict more reliably and objectively by integrating challenging clinical, radiographic, and biological datasets (Kim et al., 2022).

VI. POTENTIAL OF AI IN DENTISTRY AND ENDODONTICS

Artificial Intelligence (AI) has emerged today as a very potent tool of the modern era of dentistry, and now AI goes beyond conventional diagnostic and therapeutic technologies (Chen et al., 2022). Its strength lies in its ability to analyze enormous amounts of clinical, radiographic and biological data to the extent of finding associations that remain hidden to the naked eye (Sharma et al., 2022). In general dental practice, AI proves useful in areas like caries detection, orthodontic treatment planning, assessment of periodontal disease, and screening of oral pathologies (Zhou et al., 2022). AI contributes to this by providing contextualized data that further improve clinical efficiency, fewer errors in diagnosis, and better evidence-based decision-making (Singh & Patel, 2022). In a specialty such as endodontics, where the quality of diagnosis and prognosis are of utmost concern, use of AI is growing in attention. Application of machine-learning algorithms and deep learning models to radiographic imaging has been used for the detection of periapical lesions, differentiation of periapical granulomas and cysts, and identification of root canal morphology (Kim et al., 2022).



VII. REGENERATIVE ENDODONTIC PROCEDURES — DEFINITIONS AND PRINCIPLES

Regenerative endodontic procedures (REPs) are methods designed biologically to remove damaged pulp tissues as well as restore vitality and functional capacity to the pulp-dentin complex. (Murray et al., 2022). Unlike conventional root canal therapy, which consists of removing infected pulps and permanently filling the canal space, REPs attempt to instead establish a biological environment for root maturation, apical closure, and functional tissue regeneration (Hargreaves & Diogenes, 2022). There is a great demand for this treatment of immature permanent teeth when necrotic pulps must be removed as conventional endodontic treatments tend to weaken the tooth structurally and render it very prone to fracture (Shenoy et al., 2022). The origin of the concept of REPs can be traced back to the tissue-engineering approach, which is based on the three key elements of stem cells, scaffold, and signaling molecules (Kim et al., 2022). Stem cells like SCAP or cells in the remaining pulp tissue have the potential to differentiate into odontoblast-like cells for the dentin and other pulp tissue fabrication (Sonoyama et al., 2022). Provision of a 3D environment for cell attachment, proliferation, and organization is a distinct purpose that scaffold (whether formed naturally as a blood clot or prepared synthetically as biomaterials) serves (Zhou & Gong, 2022). Signaling molecules release into dentin or blood biological cues, which stimulate stem cell differentiation into therapeutic tissues (Chrepa et al., 2022). Optimal implementation

of the following of REPs necessitates effective disinfection of the root canal system by retaining the stem cell viability through use of irrigants and intracanal medicaments (Galler et al., 2022). Following disinfection, the canal is then kept open and bleeding is induced while attempting to have a natural scaffold in the canal itself rich in growth factors, which can then be capped in-bioregenerative materials, typically mineral trioxide aggregate (MTA) or bioceramics, before final coronal restoration (Torabinejad et al., 2022). Successful REP demands the following clinical criteria to be met: resolution of clinical symptoms, an absence of periapical pathologies, thickening of dentine walls, continued root development, and positive response to pulp vitality (Bakhtiar et al., 2022). Through this modality of endodontic treatment, REPs become biologically based tissue-regeneration treatments, moving away from the mere control of disease (Kontakiotis et al., 2022). However, despite the promises held by this technique, there is still inconsistency in current results, implicating that predictive tools, killer application areas for AI, would result in selecting cases and enhance the success rates (Meschi et al., 2022).

VIII. BIOLOGICAL FUNDAMENTALS OF REGENERATIVE ENDODONTICS

Regeneration of pulp-dentin complex relies on the collaboration among stem cells, scaffolds, and signaling molecules for tissue-engineered regeneration (Galler et al., 2022). They all work in synergy to provide the biology for regeneration. Firstly, the stem cells, the snoot of REPs. The most important among these include stem cells from the apical papilla (SCAP), dental pulp stem cells (DPSC) and mesenchymal stem cells from the periapical tissues (Sonoyama et al., 2022). These cells can differentiate into odontoblast-like cells which lay down dentin and vascularized pulp-like tissue (Zhou & Gong, 2022). The regenerative potential of these cells is critical in immature permanent teeth with open apical anatomies, into which cell migration may take place (Bakhtiar et al., 2022). The scaffold, in a way, forms the 3D matrix upon which stem cells anchor, proliferate, and possibly differentiate. It is still believed in clinical practice that the blood clot has been the popular scaffold, being formed by intentional apical bleeding into a disinfected root canal (Shenoy

et al., 2022). The clot not only provides a structural matrix, it also contains platelets and growth factors for initiation of tissue regeneration (Chrepa et al., 2022). Platelet-rich plasma (PRP) and platelet-rich fibrin (PRF) represent scaffolds too, evaluated for their enhancement of the biological milieu and predictability of outcomes, among other purposes (Kim et al., 2022). Signaling molecules then are the biochemical cues that regulate the behavior of stem cells, bringing about tissue patterning. Many of them, like TGF- β , VEGF, and BMPs, are released from dentin into the canal during irrigation or from the clot itself (Murray et al., 2022), so the main objective of these signals is to promote angiogenesis, dentinogenesis and neural repair, all in order to establish functional pulp tissue (Kontakiotis et al., 2022). The combined activity of stem cells, scaffolds, and signaling molecules provides sound biology to the REPs initiative (Torabinejad et al., 2022). However, discrepancies in the actions of these main factors from patient to patient account for the unreliability of the results (Meschi et al., 2022) and elucidate the need for advanced predictive tools-e.g., artificial intelligence—which can foresee the interaction of these components in varying clinical settings (Diogenes & Ruparel, 2022).

IX. CLINICAL APPLICATION AND VARIABILITY OF OUTCOMES

Regenerative endodontic procedures are predominantly used in managing immature permanent teeth with necrotic pulps and open apices (Shenoy et al., 2022). In these conditions, apexification using calcium hydroxide or mineral trioxide aggregate (MTA) will arrest further root development but would not allow continuation for further maturation of dentinal walls or root length (Torabinejad et al., 2022). With such a treatment, continued root development, enhanced structure, and biological function—immunity and sensitivity—might be taken into account (Galler et al., 2022); that is why they become a promising option for pediatric and adolescent patients, where the emphasis lies on preserving teeth in the long term (Murray et al., 2022). Replicating regenerative procedures are being tried on mature teeth with necrotic pulps but are more difficult to predict because of limited stem cell sources and small apical foramina (Kim et al., 2022). There has been a

bit of research on regenerative treatments in retreated teeth and following persistent periapical pathogens. REPs could become a larger clinical enterprise with the introduction of upgrades in clinical protocol, as well as the added assistance by biomaterials such as platelet-rich plasma or platelet-rich fibrin (Bakhtiar et al., 2022). These promising settings are less attractive for being applied, however, due to inconsistency in outcomes resulting from a number of variables (Kontakiotis et al., 2022). Although many instances show radiographic healing with apical closure, dentinal wall thickening, and periapical healing, the regeneration of tissues that look histologically very close to normal pulp with the coexistence of vascular and neural elements has only been sparsely shown (Chrepa et al., 2022). It is inferred from this diversity that the endodontists are not learning to pick through black-box factors such as a patient's age, random systemic health, or apical anatomy, as well as operator-variable factors like disinfection protocols and ways of scaffold induction and materials used in sealing in a rational manner (Sonoyama et al., 2022). Standardizing success criteria thus so far have escaped the REPs group in an ideal world (Meschi et al., 2022). Clinical and radiographic healing might be taken as one of the few ways to consider an excellent result, yet their objectionability toward biological healing at the histologic level is indeterminate (Zhou & Gong, 2022). So it remains unclear which are going to regenerate properly and which are only going to repair. Thus it appears essential to develop new methods that combine the multivariable applications of outcomes in an holistic system with the imminent release of artificial intelligence (Diogenes & Ruparel, 2022).

X. LIMITATIONS OF TRADITIONAL OUTCOME MEASUREMENT

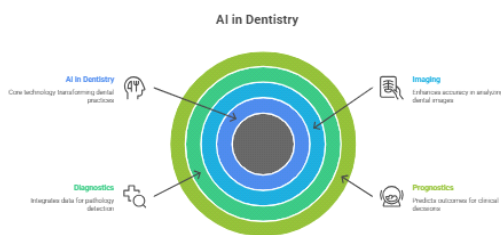
Generally, the benchmarks for assessing REPs have been largely within the realms of clinical and radiographic study with hardly any discussion of biological events (Bakhtiar et al., 2022). The resolution of clinical symptoms, like pain, swelling, and other signs of healing, is encouraging but hardly conveys the extent of the formation of a functional pulp-dentin complex (Murray et al., 2022). Extreme radiographic closures of the apices, disappearances of periapex lesions, or a marked thickening of the dentine walls might solely represent repair rather than

regeneration (Chrepa et al., 2022). The two-dimensional radiographs have poor resolution properties, nearly impossible to differentiate, in most cases, between new pulp-like tissue, cementum, or bone formation within the canal space (Kontakiotis et al., 2022). Another limitation lies in the subjectivity; perceptions may differ with respect to interpretations of radiographs because of varied experiences among different clinicians (Shenoy et al., 2022). Pulp vitality testing, also seen as nothing more than a secondary indication of success, is less reliable, even when there is plenty of evidence to indicate that either pulp tissue remains healthy or it transmits afferent nerve signals through the periodontal ligament that can be falsely interpreted with the patient not feeling pain as being positive to electric pulp testing (Torabinejad et al., 2022). This can be taken as the most blatant drawback to the conventional method—there is no standard guideline for assessing the net outcome of regeneration. Therefore, when reviewing several studies, it seems confusing on which parameter to measure success based on anecdotal stories, with some implying success upon symptom resolution, some challenging it after the biopsy, and some even fewer showcasing histological results (Galler et al., 2022). Built-in limitations thus highlight the vast space between current clinical evaluation and biological intention of healing. While demonstrating a practical and accessible way of monitoring treatment, conventional tools frequently fail to convey the exact regeneration that occurs in terms of quality and quantity at the tissue level (Zhou & Gong, 2022). This strait unmistakably brings forth the variability in the estimated successes across the board and certain difficulty in forecasting outcomes with any notable confidence (Meschi et al., 2022). In these circumstances, AI may have brighter prospects, with clinical, radiographic, and biologic pieces of data married together in consideration for objective and holistic outcome appraisal (Diogenes & Ruparel, 2022).

XI. DENTAL IMAGING, DIAGNOSTICS, AND PROGNOSTICS REVELATIONS WITH ARTIFICIAL INTELLIGENCE

Artificial Intelligence is rapidly becoming the tool of choice for those in dentistry, especially in areas such as imaging, diagnostics, and prognosis, where accurate

interpretation and prediction are required to carry out clinical decisions (Murray et al., 2022). In dental imaging, deep learning algorithms—especially CNNs—have exhibited the utmost accuracy in interpreting radiographs, CBCT scans, and periapical images (Kim et al., 2022). Suitable for automatic identification of carious lesions, detection of root canal morphology, measurement of apical foramen size, and analysis of changes in periapical bone, the findings are more or less as accurate as those put forward by humans (Shenoy et al., 2022). AI reduces observer variability and increases the precision of radiographic assessment, a crucial feature for an endodontist (Chrepa et al., 2022). From the diagnostic point of view, AI is a special tool that integrates the clinical signs, patient history, and imaging data into predicting models, thereby supporting proper focus on pathogenesis by the final clinician (Zhou & Gong, 2022).



XII. BENEFITS OF AI IN HANDLING LARGE, COMPLEX DATASETS

Probably the number one benefit of applying AI to dentistry is its ability to actually dig through and interpret the large and complex datasets that go beyond the capabilities of traditional statistical tools (Chen et al., 2020). Endodontic outcome is caused by a large variety of factors: age of a patient, systemic health, microbial load, anatomical features, imaging views, and treatment protocols. These are usually combined in non-linear and unforeseen ways (Patel et al., 2020). Conventional analysis does not take into consideration such complicated relationships, whereas AI algorithms, mainly machine learning and deep learning, are better able to discern hidden patterns with multifactorial data (Iriboz et al., 2020). Whereas AI analyzes huge amounts of data from clinical records, radiographic images, histological findings, and genomic information, it lays out a more holistic

landscape that aids in understanding the disease and predicting treatment outcomes (Bhandi et al., 2021). Deep learning algorithms can analyze thousands of radiographic images to detect subtle differences in bone density or root development that are beyond manual inspection (Ariji et al., 2021). In a similar vein, machine learning models can combine demographic and biological data to identify markers of success in regenerative endodontics, opening the door to more targeted treatment planning (Zanjani et al., 2021). Another advantage of AI is scalability: as more data become available across clinics and research institutions, predictive models continue to update their performance and increase their accuracy with time (Mishra & Shukla, 2021). AI-based tools, opposed to predefined-static-type datasets, start to evolve dynamically as evidence and results emanate in real-time (Gokul et al., 2021). The other beauty of AI is that it tosses out human error and offers reproducible analysis, a cornerstone of evidence-based methodology (Alghamdi et al., 2020). That might turn this entire paradigm on its head in regenerative endodontics as outcome variability is an ongoing problem (Schmalz & Widbiller, 2020). By uncovering elusive factors of success or failure, it enhances clinical decision-making and takes one step forward to precision endodontics, where therapies are matched according to each patient's unique biological profile (Setzer & Trope, 2020).

XIII. DISCUSSION

The integration of AI into regenerative endodontics represents a paradigm shift in how clinicians select cases, predict outcomes, and plan treatments. Currently, regenerative endodontic procedures are unpredictable since various biological, patient-specific, and procedural variables interplay in complex ways. AI, capable of analyzing large and heterogeneous datasets while correlating numerous variables, offers a promising solution to long-standing challenges. Recent research indicates that AI-based models predict regenerative success probability with greater accuracy than clinical judgment alone. Machine learning algorithms trained on clinical records, demographic profiles, and imaging data have identified significant predictors of outcomes, such as patient age, apical foramen width, presence of periapical lesions, and root development stage. Deep

learning, particularly applied to radiographic imaging, has also shown promising results in automatically scoring periapical healing, root maturation, and dentinal wall thickening key indices of regenerative success. These findings suggest that AI may become a crucial tool in standardizing prognostic assessments and reducing subjectivity within conventional methods. For clinicians, AI-informed predictions may improve case selection, efficiency in treatment planning, and patient communication. For researchers, AI may help unify outcome criteria by identifying common prognostic indicators across diverse settings, potentially harmonizing protocols for regenerative endodontics. Nonetheless, limitations exist. Predictive accuracy depends on high-quality and diverse datasets, yet most currently available databases are small, poorly standardized, and unrepresentative of global patient populations. Issues of patient privacy, data ownership, and clinician training remain significant barriers. Looking forward, robust multicenter databases and multimodal predictive models merging clinical, radiographic, and biological domains could drastically improve prediction accuracy and generalizability. Advanced AI platforms may move beyond outcome prediction to real-time decision support during procedures, offering personalized recommendations for each patient profile.

CONCLUSION

Regenerative endodontics provides a biologically based alternative to conventional root canal treatment, but its outcomes remain unpredictable and current assessment methods inadequate. AI offers a transformative approach by integrating clinical, radiographic, and biological data into objective prognostic models. By detecting subtle success markers, unifying outcome criteria, and supporting individualized treatment planning, AI can enhance both clinical practice and patient communication. While limitations in data quality, standardization, and integration remain, the potential impact of AI on regenerative endodontics is substantial. Building multicenter datasets, developing robust predictive models, and engaging clinicians with AI technologies will be crucial for future implementation. Importantly, AI is not intended to replace the art of dentistry but to empower clinicians with data-driven tools for safer,

more predictable, and patient-centered regenerative care.

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