

# Use of Dental Radiographs for Calculus Detection Post Non-Surgical Periodontal Therapy: A scoping review

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## ABSTRACT

- Purpose** Research has shown that calculus detection and removal present a persistent challenge in dentistry. The purpose of this scoping review was to determine the amount of literature regarding the use of dental radiographs for calculus detection and removal following nonsurgical periodontal therapy.
- Methods** The following questions guided the review: 1) To what extent are radiographs incorporated into clinical practice for calculus detection and what factors influence their use or limitations? 2) What role do radiographs play in verifying the effectiveness of calculus removal during periodontal therapy? 3) Should a protocol or clinical guideline for use of dental radiographs post-nonsurgical periodontal therapy be considered? Following PRISMA guidelines, an online search of PubMed, CINAHL, Cochrane Database of Systematic Reviews, JBI EBP Database, and Web of Science was conducted. Inclusion criteria were studies conducted on the presence of dental calculus, calculus detection, calculus removal and evaluation methods. Studies with a sample size of fewer than thirty, studies on implants, animals, in vitro studies, and research that did not include calculus detection or removal in the topic were excluded from the review.
- A total of 346 articles underwent title and abstract screening by three separate reviewers for assessment against the inclusion criteria for the review.
- Results** A total of 59 studies met the inclusion criteria for the scoping review. Only two of the articles explicitly mentioned using radiographs to detect calculus. While a wide range of techniques were employed for calculus detection and removal, no single method was universally effective, and many studies acknowledged the persistent challenge of residual calculus post-nonsurgical periodontal treatment.
- Conclusion** When combined with traditional calculus detection methods, the use of radiographs alone, or in combination with AI techniques, may prove beneficial post-nonsurgical periodontal therapy. While the concept of assessing subgingival calculus via radiographs is not novel, findings highlight a significant gap in the literature validating its effectiveness. Additionally, research on AI assisted radiographic calculus detection should be focused on in-vivo studies to reflect real scenarios and whether these techniques improve patient outcomes.
- Keywords** non-surgical periodontal therapy, calculus detection, radiographs, treatment outcomes, clinical care protocols
- NDHRA priority area, **Client level: Oral health care** (new therapies and prevention modalities)
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## INTRODUCTION

Periodontal disease is a chronic inflammatory condition linked to systemic health conditions. Because dental calculus is a local contributor to periodontal disease, its effective removal is essential.<sup>1</sup> Dental calculus harbors bacteria, impairs host inflammatory responses, and correlates with deeper periodontal pocket depth and clinical attachment loss.<sup>1</sup> However, research has shown that calculus detection and removal remain a persistent challenge in dentistry.<sup>1</sup> The goal of subgingival instrumentation on periodontally involved roots is to remove all biofilm and mineralized deposits while keeping the cementum intact.<sup>2-3</sup> Differentiating between residual calculus and natural tooth anatomy and effective calculus removal continues to present a clinical challenge.<sup>3</sup> Several studies have been conducted to assess calculus detection including using endoscopy, spectro-optical technology, autofluorescence, and the dental explorer or periodontal probe.<sup>3-11</sup> Each of these studies cite limitations of the various calculus detection methods.<sup>3-11</sup> Additionally, there have been numerous studies conducted to assess calculus removal utilizing techniques such as dental lasers, hand scaling versus ultrasonics, videoscopes and endoscopes, gingival retraction cords, gels, and flap surgery. While each of these studies demonstrated that subgingival scaling and non-surgical periodontal therapy are effective, multiple systematic reviews of calculus removal methods show that they can leave residual subgingival calculus.<sup>12-13</sup> Most studies addressing the accuracy of calculus detection and removal during nonsurgical periodontal therapy are performed on periodontally involved extracted teeth in vitro, while clinicians face the challenge of effective sub-gingival calculus removal on teeth that are present in the oral cavity.<sup>14</sup>

Dental radiographs are a useful diagnostic tool in dentistry, but their use in detecting subgingival calculus is not well understood.<sup>6,15</sup> Additionally, the Federal Drug Administration (FDA) does not discuss utilizing radiographs post nonsurgical periodontal therapy or for detecting the presence of calculus.<sup>16</sup> In 1994, an expert panel considered adding periodontal-

specific radiographic guidelines; however, due to insufficient literature relating to selection criteria for periodontology, the panel determined that radiography should serve as secondary to clinical examination in the periodontal assessment process.<sup>15</sup> Current FDA guidelines reiterate that radiographic examination after nonsurgical periodontal therapy should focus on bone levels and changes rather than the detection of calculus.<sup>16</sup> New technologies have included the use of Artificial Intelligence (AI) integrated within dental software to aid in diagnostics. Calculus detection is one of the available features of AI in dental software that utilizes computer vision algorithms trained on large datasets of annotated dental radiographs.<sup>17</sup>

Radiographs are primarily used for detection of caries, bone loss, and other orofacial pathologies. While the use of radiographs to evaluate the efficacy of subgingival calculus removal has not been reported in the literature, it may be used frequently in clinical practice settings.<sup>11</sup> There is a gap in the literature on the use of radiographs following non-surgical periodontal therapy. The purpose of this scoping review was to explore the literature regarding the use of radiographs following non-surgical periodontal therapy. The following questions guided the review:

1. To what extent are radiographs incorporated into routine practice for detecting calculus, and what factors influence their use or limitations?
2. What role do radiographs have in verifying the effectiveness of calculus removal during periodontal therapy?
3. Should a protocol or clinical guideline for use of dental radiographs post-nonsurgical periodontal therapy be considered?

## METHODS

The JBI (formerly the Joanna Briggs Institute) methodology for scoping reviews and the Preferred Reporting Items for Systematic Reviews and Meta-analyses extension for scoping reviews (PRISMA-ScR) were used to guide this review.<sup>18-20</sup>

## Inclusion Criteria

The review focused on original research papers and clinical trials published in academic journals that included studies on the presence of dental calculus, calculus detection, calculus removal and evaluation methods. The exclusion criteria were sample size of fewer than thirty, studies on implants, animals, in vitro studies, and research that did not include calculus detection or removal in the topic. Articles in other languages were omitted when English translation was not available, as well as articles that were not considered original research, such as narrative reviews (Table I).

**Table I. Inclusion/exclusion criteria**

| Inclusion Criteria                                   | Exclusion Criteria                                            |
|------------------------------------------------------|---------------------------------------------------------------|
| Original research                                    | In Vitro studies (fake calc/teeth, extracted teeth, implants) |
| Methods for calculus detection or removal            | Sample size less than 30                                      |
| Use of radiographs for calculus detection or removal | Animal studies                                                |
| Systematic reviews                                   | Unable to translate                                           |
|                                                      | Not original research (including narrative reviews)           |

The primary concepts explored were the techniques and effectiveness of calculus detection and removal, with an emphasis on the role radiographs may play in identifying calculus deposits.

Studies were reviewed across diverse publications in various dental settings to evaluate the current utilization of radiographic imaging in calculus detection, identifying limitations in existing methodologies and potential areas for future research.

## Sources and Search Strategy

This scoping review exclusively considered peer-reviewed research and primarily quantitative, clinical experimental designs. There were no limitations

regarding the date, status, or language of publications provided and English translation was available, nor when or where the research studies were conducted. The search strategy aimed to locate both published and unpublished studies and was developed with the input of a clinical services librarian (RL).

An initial limited search of PubMed (NCBI) and CINAHL (EBSCO) was undertaken to identify articles on the topic. The keywords contained in the titles and abstracts of relevant articles, and the subject headings used to describe the articles were used to develop a full search strategy for PubMed (NCBI), CINAHL (EBSCO), Cochrane Database of Systematic Reviews (CDSR), JBI EBP Database (OVID), and Web of Science (Clarivate). The search strategy, including all identified keywords and subject headings, was adapted for each included database and run from inception. The searches were last run on 03 December 2024 in each database. In addition, the reference lists of the included studies were manually checked, and a backward and forward citation analysis was performed and searched. All publication types and languages were included in the search.

## Evidence Selection

Following the search, 568 identified citations were collated and uploaded into a citation software program (EndNote™; Clarivate, Philadelphia, PA, USA) and 222 duplicates were removed.<sup>21</sup> The final 346 articles underwent title and abstract screening by three separate reviewers (TW, CR, JS) for assessment against the inclusion criteria for the review. A description of the selection process is shown in Table II. Any conflicts between reviewers during any stage of the selection process were resolved through discussion and further reviewing of the abstracts.

Three categories were created and color coded: Exclude (red), Possibly include (yellow), and Include (green). Notes were taken in each category as to why sources were placed within their respective category. One hundred fourteen potentially relevant records were identified, and full text was sought for retrieval; three articles were not available in full text.

**Table II. PRISMA-ScR description of the selection process**

| Identification                                                                                                                                                                                                                                                                                                                 |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Databases searched: PubMed, CINAHL, Cochrane Database of Systematic Reviews, JBI EBP Database, Web of Science                                                                                                                                                                                                                  |
| Records identified (n=568)                                                                                                                                                                                                                                                                                                     |
| Duplicate records removed prior to screening (n= 222)                                                                                                                                                                                                                                                                          |
| Screening                                                                                                                                                                                                                                                                                                                      |
| Records excluded based on title and abstract (n=232)                                                                                                                                                                                                                                                                           |
| Reports not screened (n=3)                                                                                                                                                                                                                                                                                                     |
| Reports excluded (n=288)                                                                                                                                                                                                                                                                                                       |
| <ul style="list-style-type: none"><li>• In vitro - extracted teeth, fake calculus/teeth, implants (n=88)</li><li>• Small sample size (n=46)</li><li>• Animal studies (n=6)</li><li>• Non research (n=20)</li><li>• Unable to translate (n=4)</li><li>• Not related to the topic (n=121)</li><li>• No full text (n=3)</li></ul> |
| Included                                                                                                                                                                                                                                                                                                                       |
| Studies included in review (n=59)                                                                                                                                                                                                                                                                                              |
| <ul style="list-style-type: none"><li>• Calculus detection (n=9)</li><li>• Calculus removal (n=50)</li></ul>                                                                                                                                                                                                                   |

Independent reviewers thoroughly evaluated the full text of selected citations against the inclusion criteria, with any disagreements resolved as previously described. Reasons for the exclusion of sources of evidence at full-text assessment that did not meet the inclusion criteria were recorded and reported (Table II). A total of 59 articles were included in this scoping review, including 8 clinical trials.

For studies published in languages other than English, CoPilot (Microsoft, Bellevue, WA, USA) was used to determine whether the study met the inclusion criteria. One article that discussed clinical evaluation of manual and ultrasonic scaling using image analysis was translated and included.

### Data Extraction

Verification of the study quality was not conducted as the purpose of this scoping review was to understand the research regarding dental radiographs for calculus detection and removal. Data extraction from the articles was performed on a spreadsheet. Fields for data extraction were based on relevance to calculus detection and removal using different techniques. Three investigators were involved in the data extraction process (TW, CR, JS). A data extraction table was used for content analysis.

## RESULTS

### Calculus Detection

Nine of the studies discussed calculus detection and emphasized four techniques including light-based technologies, periodontal probing, radiographic imaging, and the use of advanced technology such as endoscopy. Four studies used light-based technology as a method for calculus detection,<sup>3,7-9</sup> while one study discussed the use of the periodontal probe for calculus detection.<sup>10</sup> Only two studies utilized radiographs for calculus detection,<sup>4,6</sup> while two other studies discussed advanced technology, such as the endoscope, for calculus detection.<sup>5,11</sup>

Upon reviewing all selected sources, all but one author acknowledged, within the results and discussion sections, that detecting calculus remains a difficult and often unreliable process, even in the context of their own studies.<sup>3-11</sup>

### Calculus Removal

Fifty of the studies included in this review addressed techniques for calculus removal. Reported methods included the use of burs, endoscopes, flap surgery, gels, gingival retraction cord, hand instruments, lasers, and ultrasonic devices. One study discussed bacteria in relation to calculus, but it was not presented as a method of removal.<sup>22</sup> There were two articles that discussed the use of burs for calculus removal.<sup>23-24</sup> Nine studies discussed utilizing an endoscope, videoscope, or air polisher for calculus removal.<sup>25-33</sup> Three studies

focused specifically on flap surgery.<sup>34-36</sup> There were eleven articles on gels such as Edmogain (Biora AB, Malmo, SE)<sup>37-47</sup> and one that discussed the use of a gingival retraction cord in deposit removal.<sup>48</sup> There were six articles on hand instrumentation<sup>49-54</sup> and an additional six on lasers.<sup>55-60</sup> There was one study on oral health education and motivational interviewing prior to deposit removal procedures<sup>61</sup> while one study discussed the utilization of loupes.<sup>62</sup> Ten studies examined the use of ultrasonic devices for calculus removal.<sup>63-71</sup> A comprehensive overview of the included studies by title, type and topic (n=58) is shown in Table III.

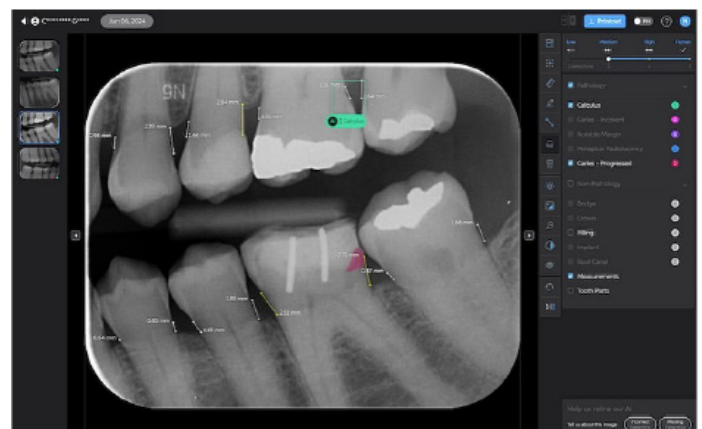
## DISCUSSION

Across the reviewed studies, a consistent theme emerged. While a wide range of techniques from hand instruments and ultrasonics to lasers, gels, and endoscopes were employed for calculus removal, no single method was universally effective, and many studies acknowledged the persistence of residual calculus post-treatment. This highlights the ongoing challenge in achieving complete debridement and the need for enhanced detection and verification tools in clinical practice.

Radiographs are a routine diagnostic tool in clinical practice, however, their role in detecting or confirming the presence of calculus is rarely studied. Across the nine calculus detection studies, authors consistently noted that calculus detection is difficult and unreliable, even with advanced tools such as optical probes, optical coherence tomography (OCT), ultrasonic devices, and endoscopy. Radiographic detection was reported in only two studies, reinforcing the limited evidence for this approach.<sup>4,6</sup> In contrast, the calculus removal studies (n=50) evaluated a wide range of techniques such as hand instrumentation, ultrasonic scalers, periodontal endoscopy, lasers, gels, and adjunctive agents, yet residual calculus remained common finding. These findings also highlight a significant research gap concerning the application of radiographs for calculus identification, underscoring the need for further investigation to establish diagnostic protocols and best practices in dental hygiene and periodontal care.

Results from this scoping review are foundational because they illustrate that while clinicians rely heavily on radiographs in practice, there is little evidence to support their use for verifying calculus removal. Clinicians rely on tactile assessment and visual cues, which can be subjective because they are dependent on individual experience and skill, therefore are prone to inconsistency. This review identifies the value of exploring radiographic and the possibility of utilizing Artificial Intelligence (AI) assisted methods as adjuncts to improve accuracy of calculus detection and removal. One example of this emerging technology is a pre-trained AI-based computer-aided detection software that marks suspected calculus on radiographs (Figure 1).<sup>17</sup> This software recognizes radiopaque deposits on the tooth surface and is designed to detect subtle changes on low-contrast images that may conceal early subgingival calculus which is often difficult for the human eye to discern.<sup>17</sup> Because human interpretation can be subjective and prone to variability for subtle changes such as dental calculus when considering factors such as image quality, receptor type, and complex dental anatomy, AI may help standardize interpretations. However, current AI tools should be considered adjunctive, as they can produce false positives and require further validation in clinical settings. Clinicians should critically evaluate the effectiveness of current detection and removal techniques and consider integrating multiple modalities to improve outcomes.

**Figure 1. Image of Artificial Intelligence software detecting calculus and other dental findings on a radiograph.<sup>17</sup>**



**Table III. Overview of the research reviewed on calculus detection and removal by category, title, type, topic and use of radiographs**

| Category           | Title                                                                                                                                            | Study Type                        | Topic                                         | Radiographic Use |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|-----------------------------------------------|------------------|
| Calculus Detection | Optical diagnostics in periodontology                                                                                                            | Literature Review                 | Light technology                              | No               |
| Calculus Detection | Auxiliary diagnosis of dental calculus based on deep learning and image enhancement by bitewing radiographs                                      | Experimental                      | Radiography                                   | Yes              |
| Calculus Detection | Optical coherence tomography follow-up of patients treated from periodontal disease                                                              | Observational                     | OCT, Optical probe                            | No               |
| Calculus Detection | Calculus detection technologies: Where do we stand now?                                                                                          | Literature Review                 | Endoscopy, Spectro-Optical Technology,        | No               |
| Calculus Detection | The effectiveness of subgingival scaling and root planning. I. Clinical detection of residual calculus                                           | Experimental                      | Ultrasonic scaler, Hand Instruments           | No               |
| Calculus Detection | The effect of subgingival calculus on the validity of clinical probing measurements                                                              | Observational                     | Diamond-coated ultrasonic tips, Optical probe | No               |
| Calculus Detection | Clinical subgingival calculus detection with a smart ultrasonic device: a pilot study                                                            | Pilot study                       | Ultrasonic scaler                             | No               |
| Calculus Detection | Accuracy of dental calculus detection using digital radiography and image manipulation                                                           | Experimental                      | Radiography                                   | Yes              |
| Calculus Detection | The effectiveness of a novel optical probe in subgingival calculus detection                                                                     | Experimental                      | Optical probe                                 | No               |
| Calculus Removal   | Effectiveness of subgingival scaling and root planing: Single versus multiple episodes of instrumentation                                        | Randomized Controlled Study       | Hand instruments, Optical probe               | No               |
| Calculus Removal   | Effects of periodontal endoscopy on the treatment of periodontitis: A systematic review and meta-analysis                                        | Systematic review & meta-analysis | Periodontal endoscope                         | No               |
| Calculus Removal   | The relationship between bleeding on probing and subgingival deposits. An endoscopic evaluation                                                  | Cross-sectional Clinical          | Periodontal endoscope                         | No               |
| Calculus Removal   | Comparative evaluation of manual scaling and root planing with or without magnification loupes using scanning electron microscope: A pilot study | Comparison                        | Loupes; Hand Instruments                      | No               |
| Calculus Removal   | Evaluation of root surface roughness produced by hand instruments and ultrasonic scalers: An in vivo study                                       | Comparison                        | Hand instruments, Ultrasonics                 | No               |
| Calculus Removal   | Root surface changes following manual and ultrasonic instrumentation - A scanning electron microscopic study                                     | Control Study                     | Hand instruments, Ultrasonic scaler           | No               |
| Calculus Removal   | Fiber optic probe augmented sonic scaling versus conventional sonic scaling                                                                      | Randomized Controlled Study       | Optical probe, Ultrasonic scaler              | No               |

**Table III. Overview of the research reviewed on calculus detection and removal by category, title, type, topic and use of radiographs (Cont.)**

| Category         | Title                                                                                                                                                       | Study Type                              | Topic                                            | Radiographic Use |
|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|--------------------------------------------------|------------------|
| Calculus Removal | Clinical evaluation of the speed and effectiveness of subgingival calculus removal on single-rooted teeth with diamond-coated ultrasonic tips               | Controlled Comparison                   | Diamond-coated ultrasonic tips, Hand instruments | No               |
| Calculus Removal | Comparative effectiveness of ultrasonic and hand scaling for the removal of subgingival plaque and calculus                                                 | Comparison                              | Hand instruments, Ultrasonic scaler              | No               |
| Calculus Removal | A comparison of root surface instrumentation using two piezoelectric ultrasonic scalers and a hand scaler in vivo                                           | Comparison                              | Hand instruments, Piezoelectric ultrasonic       | No               |
| Calculus Removal | Efficacy of subgingival calculus removal with Er:YAG laser compared to mechanical debridement: An in-situ study                                             | Comparison                              | Laser, Hand instruments                          | No               |
| Calculus Removal | Effect of Er:YAG laser on diseased root surfaces: An in vivo study                                                                                          | Randomized Controlled Study             | Laser                                            | No               |
| Calculus Removal | The effectiveness of scaling and root planing with curets designed for deep pockets                                                                         | Control Study                           | Hand instruments                                 | No               |
| Calculus Removal | A clinical and SEM evaluation of the efficiency of softscale gel and hand scaling and hand scaling alone                                                    | Control Study                           | Hand instruments, Ultrasonic scaler, Gel         | No               |
| Calculus Removal | The effectiveness of subgingival scaling and root planing in calculus removal                                                                               | Control Study                           | Hand instruments, Stereomicroscope               | No               |
| Calculus Removal | Root planing following short-term pocket distention                                                                                                         | Randomized Controlled Study             | Retraction Cord                                  | No               |
| Calculus Removal | Chemical cleansing as an adjunct to subgingival instrumentation with ultrasonic and hand devices in deep periodontal pockets: a randomized controlled study | Randomized Controlled Study             | Hand instruments, Ultrasonic scaler              | No               |
| Calculus Removal | Effect of locally delivered doxycycline hyclate on human fibroblast attachment to subgingival calculus                                                      | Mixed Methods                           | Antibiotic Doxycycline                           | No               |
| Calculus Removal | The effects of EDTA gel conditioning exposure time on periodontitis-affected human root surfaces: surface topography and PDL cell adhesion                  | Comparison                              | EDTA gel                                         | No               |
| Calculus Removal | Root surface characteristics associated with subgingival placement of monolithic tetracycline-impregnated fibers                                            | Randomized Controlled Study             | Antibiotic Tetracycline                          | No               |
| Calculus Removal | Subgingival scaling and root planing during minimally invasive periodontal surgery: A randomized controlled split-mouth trial                               | Randomized Controlled Split Mouth Study | Periodontal endoscope, Videoscope                | No               |
| Calculus Removal | The effectiveness of subgingival scaling and root planing: an evaluation of therapy with and without the use of the periodontal endoscope                   | Randomized Controlled Study             | Periodontal endoscope                            | No               |

**Table III. Overview of the research reviewed on calculus detection and removal by category, title, type, topic and use of radiographs (Cont.)**

| Category         | Title                                                                                                                                                                    | Study Type                            | Topic                                         | Radiographic Use |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|-----------------------------------------------|------------------|
| Calculus Removal | Diamond burs versus curettes in root planing: a randomized clinical trial                                                                                                | Randomized/ Controlled Clinical Trial | Diamond-coated ultrasonic tips, Hand curettes | No               |
| Calculus Removal | Utilization of a periodontal endoscope in nonsurgical periodontal therapy: A randomized, split-mouth clinical trial                                                      | Randomized Split-Mouth Clinical Trial | Periodontal endoscope                         | No               |
| Calculus Removal | Videoscope-assisted minimally invasive periodontal surgery (V-MIS)                                                                                                       | Prospective Cohort                    | Periodontal endoscope, Videoscope             | No               |
| Calculus Removal | Calculus removal by scaling/root planing with and without surgical access                                                                                                | Randomized Controlled Study           | flap surgery                                  | No               |
| Calculus Removal | A pilot study comparing the outcome of scaling/root planing with and without Perioscope™ technology                                                                      | Randomized Convenience Sample         | Periodontal endoscope                         | No               |
| Calculus Removal | The efficacy of subgingival calculus removal with endoscopy-aided scaling and root planing: a study on multicrooked teeth                                                | Randomized Controlled Study           | Periodontal endoscope                         | No               |
| Calculus Removal | Prognostic criteria for the efficiency of non-surgical periodontal therapy in advanced periodontitis                                                                     | Prospective Cohort                    | Radiography, Bacteria                         | No               |
| Calculus Removal | [Clinical evaluation of manual and ultrasonic subgingival scaling using image analysis]                                                                                  | Comparison                            | Hand instruments, Ultrasonic scaler           | No               |
| Calculus Removal | Calculus removal from multicrooked teeth with and without surgical access. II. Comparison between external and furcation surfaces and effect of furcation entrance width | Comparison                            | Diamond-coated ultrasonic tips                | No               |
| Calculus Removal | Effect of an Er:YAG laser on periodontally involved root surfaces: an in vivo and in vitro SEM comparison                                                                | Comparison                            | Laser, Hand Instruments                       | No               |
| Calculus Removal | Manual debridement more effective than Er:YAG laser irradiation                                                                                                          | Comparison                            | Laser, Hand Instruments                       | No               |
| Calculus Removal | Effectiveness of a prescale gel on subgingival calculus                                                                                                                  | Randomized Controlled Study           | Pre-scale Gel                                 | No               |
| Calculus removal | Evaluation of root roughness and smear layer formation using conventional and contemporary dental curettes                                                               | Clinical Trial                        | Hand instruments                              | No               |
| Calculus Removal | An evaluation of the root topography following periodontal instrumentation--a scanning electron microscopic study                                                        | Control Study                         | Hand instruments, Ultrasonic scaler, SEM      | No               |

**Table III. Overview of the research reviewed on calculus detection and removal by category, title, type, topic and use of radiographs (Cont.)**

| Category         | Title                                                                                                                                                                                                                                                                   | Study Type                                  | Topic                                 | Radiographic Use |
|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|---------------------------------------|------------------|
| Calculus Removal | The effect of various ultrasonic and hand instruments on the root surfaces of human single rooted teeth: A Planimetric and Profilometric study                                                                                                                          | Planimetric and Profilometric               | Hand instruments, Ultrasonics         | No               |
| Calculus Removal | The effectiveness of hand versus ultrasonic instrumentation in open flap root planing                                                                                                                                                                                   | Comparison                                  | Hand instruments, Ultrasonic scaler   | No               |
| Calculus removal | Comparative clinical evaluation of the effect of local application of calculus solution in softening and effortless removal of calculus as compared to conventional hand scaling in patients with calculus build up.                                                    | Clinical Trial                              | Hand instruments                      | No               |
| Calculus removal | The use of a non-incised minimally invasive flap procedure in conjunction with Emdogain® MI compared to traditional SRCP                                                                                                                                                | Clinical Trial                              | Hand instruments Emdogain             | No               |
| Calculus Removal | Effectiveness of root planing with diode laser curettage for the treatment of periodontitis                                                                                                                                                                             | Randomized Controlled Study                 | Laser                                 | No               |
| Calculus Removal | A clinical evaluation of the effects of a periodontal scaling gel                                                                                                                                                                                                       | Split-mouth Design                          | Hand instruments                      | No               |
| Calculus Removal | Comparative evaluation of the efficacy of local administration of Curcumin gel and Metformin gel as an adjunct to non-surgical periodontal therapy– A 3-Arm parallel randomized control trial                                                                           | Clinical Trial                              | Hand Scaling, Gel                     | No               |
| Calculus Removal | Efficacy of Carisolv as an adjunctive therapy to scaling and root planing on subgingival calculus removal                                                                                                                                                               | Randomized Controlled Study                 | Carisolv Gel                          | No               |
| Calculus Removal | Comparative evaluation of salivary macrophage inflammatory protein -1a (MIP-1a) levels in periodontitis subjects post photo-biomodulation combined with non-surgical periodontal therapy and non-surgical periodontal therapy alone: A prospective interventional study | Clinical Trial                              | Oral Health Education                 | No               |
| Calculus Removal | Effect of locally-applied simvastatin on clinical attachment level and alveolar bone in periodontal maintenance patients                                                                                                                                                | Clinical Trial                              | Simvastatin                           | No               |
| Calculus Removal | Flapless application of enamel matrix derivative in class II mandibular furcation defects                                                                                                                                                                               | Clinical Trial                              | Motivational Interviewing             | No               |
| Calculus Removal | Effectiveness of adjunctive therapy of Emdogain®FL in non-surgical periodontal treatment                                                                                                                                                                                | Clinical Trial                              | Emdogain FL                           | No               |
| Calculus Removal | Clinical outcomes following periodontal surgery and root surface decontamination by erythritol-based air polishing: a randomized, controlled, clinical pilot study                                                                                                      | Randomized Controlled, Clinical Pilot Study | Air Polisher                          | No               |
| Calculus Removal | Scaling and root planing with and without periodontal surgery                                                                                                                                                                                                           | Comparison                                  | Periodontal Surgery, Hand Instruments | No               |

Advancing detection and verification methods holds potential to reduce disease recurrence and enhance long-term periodontal stability underscoring the clinical significance of this scoping review.

### **Future Directions**

Future research should focus on in-vivo studies that evaluate radiographic and AI-assisted detection, the use of standardized imaging protocols, and the extent to which these approaches improve patient outcomes. Collaboration between dental professionals, radiologists, and AI developers will be essential to create reliable tools that support clinical decision-making.

Current FDA and American Dental Association guidelines do not include calculus detection as a valid indication for radiographic imaging. However, the current clinical use of radiographic imaging post-nonsurgical periodontal therapy coupled with the option of AI enhancement of calculus may warrant a re-evaluation of the guidance.

Gaps in the literature indicate more research on post-nonsurgical periodontal therapy imaging should be performed to establish diagnostic protocols and best practices in dental hygiene and periodontal care. Research should also consider whether these techniques improve patient outcomes and reduce re-treatment rates. There are also opportunities for interprofessional collaboration between AI developers, radiologists, and dental professionals. These collaborations could improve dental software for radiographic interpretation and diagnosis.

### **Limitations**

While this scoping review adhered to established methodology, it was the first of its kind conducted by three of the reviewers, which may have contributed to the possibility that some relevant details may have been inadvertently overlooked. The findings of this review are based on articles that met the inclusion criteria. Certain exclusion criteria may have impacted the generalizability of the findings.

## **CONCLUSION**

When combined with traditional methods, using radiographs for post-nonsurgical periodontal therapy calculus detection alone or in combination with AI techniques may prove beneficial. While the idea of assessing subgingival calculus via radiographs is not novel, findings from this scoping review highlight a significant gap in the literature regarding their validity and effectiveness. Research on AI assisted radiographic calculus detection should be focused on in-vivo studies to reflect real scenarios and whether these techniques improve patient outcomes.

### **IMPLICATIONS FOR DENTAL HYGIENE PRACTICE**

- Extensive research indicates that accurate calculus detection remains a persistent challenge, regardless of the methodology employed.
- Very few clinical research studies evaluate post-operative radiographs as part of the evaluation process of non-surgical periodontal treatment outcomes, revealing a significant gap in standardized clinical treatment protocols.
- While post-operative radiographs may offer clinical benefits in assessing therapeutic outcomes of non-surgical periodontal therapy, further research is required to establish definitive protocols.

## **DISCLOSURES**

The authors have no conflicts of interest to disclose.

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