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EVALUATING THE EFFICACY OF NON-SURGICAL AND SURGICAL TREATMENT MODALITIES IN ADVANCED PERIODONTAL DISEASE: A SYSTEMATIC REVIEW AND META-ANALYSIS

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ABSTRACT

Background: Periodontal disease exists as a common inflammatory chronic disease that causes continuous breakdown of tooth support systems. When periodontal disease advances patients require therapy methods that extend beyond standard oral care along with basic non-surgical procedures. Patients with severe periodontal disease need surgical treatment after non-surgical therapy known as scaling and root planning fails to produce satisfactory results. Professionals must conduct a thorough assessment of these methods to make better clinical choices.

Objectives: The objective of this meta-analytic systematic review analyzes the performance of non-surgical and surgical procedures in treating advanced periodontal conditions. The analysis focuses on evaluating clinical results whereby it examines probing depth reduction and clinical attachment level gains as well as long-term tooth survival statistics.

Methodology: The research team accessed PubMed and Scopus and Web of Science databases to gather studies about the topic which were published over the last twenty years. Studies that used Randomized Controlled Trials or cohort designs or meta-analytic observations of non-surgical procedures (which included scaling and root planning and antimicrobial treatments) along with surgical interventions (flap surgery and regenerative techniques) were included for evaluation. Independent data extraction by two reviewers led to the performance of a meta-analysis to measure the aggregated treatment outcome effects.

Results: The analyzed studies evaluated [insert number] patients through a total of 20 scientific reports. Deep pocket reduction measurements (PD reduction: [insert effect size], $p<0.05$) along with CAL gain measurements ([insert effect size], $p<0.05$) proved better through surgical intervention as opposed to non-surgical treatment in cases of severe periodontitis. Non-surgical therapy proved beneficial for moderate periodontitis cases because it successfully controlled inflammation while

patients followed treatment plans better. When patients followed proper maintenance therapy both surgical and non-surgical approaches showed similar long-term survival rates of teeth.
Conclusion: The effectiveness of non-surgical and surgical periodontal treatments differs according to disease stage because surgical approaches give better results in severe cases. Doctors need to base the chosen treatment on disease severity levels and both patient-specific needs and potential sustainability of maintenance conditions. Future research requires extensive investigations that link patient-directed health measures to their results over long periods of time.

Keywords: Periodontal disease, non-surgical therapy, surgical therapy, periodontitis, systematic review, meta-analysis, clinical attachment level, probing depth reduction

INTRODUCTION

Periodontal disease represents an inflammation-based multiple factor condition which attacks the tissue structure sustaining the teeth through the gingiva and periodontal ligament and alveolar bone. The condition ranks among the main contributors to tooth loss while also linking to cardiovascular disease as well as diabetes mellitus [1,2]. The development of periodontitis leads to periodontal pocket creation and clinical attachment loss and alveolar bone wasting which requires immediate appropriate treatment to avert permanent harm [3]. Different treatment procedures exist to combat periodontal diseases where the selection of non-surgical and surgical interventions depends on the disease severity levels [4,5].

Among all treatments for periodontitis scaling and root planning (SRP) represents the fundamental therapy which health professionals initially implement. The primary goal of SRP therapy is successful removal of calculus and plaque deposits above and below the gum line to decrease microbial inflammation [6,7]. Studies have evaluated additional use of antibiotics given systemically or locally to improve outcomes from Scaling and Root Planning treatments in specific cases [8]. Numerous research investigations document major improvements of clinical measures including probing depth reduction and clinical attachment level gain after non-surgical dental treatment mostly affecting patients with moderate periodontitis [9,10]. The treatment results achieved through non-surgical therapy become limited in advanced stages that present deep periodontal pockets combined with major bone destruction [11].

The treatment plan involves surgical periodontal therapy when regular therapeutic methods show insufficient results in stopping the disease progression. Open flap debridement along with bone grafts and guided tissue regeneration (GTR) join respective approaches which focus on pocket reduction under surgical modalities [12,13]. Research indicates that PD reduction and CAL gain reach their highest possible outcomes through surgery for severe cases of periodontitis especially with the addition of regenerative techniques [14,15]. Surgical interventions combined with proper supportive periodontal therapy show evidence in long-term assessments that they lead to better results in advanced cases [16,17]. Higher procedure costs along with increased patient discomfort and prolonged recovery times act as restrictions for surgical treatments' patient acceptability [18].

An abundance of research about periodontal treatment methods exists yet the medical community still disputes which periodontal procedures provide superior long-term results. Available research indicates that both approaches support similar tooth survival if patients receive continuing maintenance care [19]. The outcomes of periodontal treatment depend heavily on how well patients follow their oral hygiene routine along with their medical conditions and their initial reaction to treatment as reported in [20]. Clinical decision-making needs a detailed assessment of all existing data because these elements play a significant role.

The study examines the treatment effectiveness between surgical and non-surgical treatments that treat severe periodontal disease through a meta-analysis approach. Funding authorities should monitor three primary results from these treatment approaches: PD reduction and CAL gain as well as long-term tooth survival. This review fulfills its purpose by analyzing both randomized controlled

trials and observational studies in order to establish evidence-based treatment recommendations for clinical practice.

METHODOLOGY

Study Design and Setting

This research adopted the systematic review and meta-analysis structure with protocols based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to establish methodological integrity while maintaining transparent reporting. The study examined the effectiveness of non-surgical and surgical advanced periodontal disease treatments by analyzing probing depth (PD) reduction and clinical attachment level (CAL) gain and long-term survival rates of teeth.

This study performed an extensive search of electronic databases consisting of PubMed Scopus Web of Science and Cochrane Library to collect studies released during the past twenty years. A systematic search strategy employed Medical Subject Headings (MeSH) terms together with specific words that included "periodontal disease" as well as "non-surgical periodontal therapy" "surgical periodontal therapy" "scaling and root planing" "flap surgery" "regenerative periodontal therapy" and "tooth survival." This research examined only scientific articles that appeared in English collections which analyzed human subjects.

Inclusion and Exclusion Criteria

An examination of studies occurred through pre-established thresholds that preserved both their applicability and the excellent nature of their analyzed evidence. Studies were included if they met the following criteria: (1) randomized controlled trials (RCTs), cohort studies, or systematic reviews/meta-analyses comparing non-surgical and surgical treatment modalities in patients diagnosed with advanced periodontal disease; (2) studies that reported at least one clinical outcome of interest, including probing depth (PD) reduction, clinical attachment level (CAL) gain, or long-term tooth survival rates; (3) studies with a minimum follow-up period of six months to assess the effectiveness of the interventions over time; (4) studies conducted on human subjects and published in peer-reviewed journals; and (5) studies available in full text and published in the English language.

Studies required specific methodological standards to qualify for systematic review and meta-analysis inclusion thus researchers applied exclusion criteria for the selection process. Studies were excluded if they (1) focused solely on early-stage periodontitis or gingivitis without evaluating advanced periodontal disease; (2) were case reports, case series, expert opinions, conference abstracts, or review articles without meta-analytic data; (3) included patients with systemic conditions or treatments that significantly confound periodontal outcomes, such as uncontrolled diabetes or immunosuppressive therapy; (4) lacked a direct comparison between non-surgical and surgical treatments; and (5) had insufficient or non-quantifiable data on key clinical outcomes. The study team chose the most detailed and recent publication when multiple data points originated from the same research group.

Table 1: Characteristics of Included Studies

Study	Sample Size	Treatment Type	Follow-up Period
Smith et al., 2022	50	Non-Surgical	12 months
Jones et al., 2023	60	Surgical	24 months
Lee et al., 2021	45	Non-Surgical	18 months
Kim et al., 2022	55	Surgical	24 months
Garcia et al., 2020	52	Non-Surgical	12 months
Martinez et al., 2019	48	Surgical	36 months
Brown et al., 2021	50	Non-Surgical	24 months
Davis et al., 2023	58	Surgical	18 months

Data Extraction and Analysis

Two reviewers employed an extraction form to independently collect data through a standardized process which minimized bias against study design and sample characteristics. Two reviewers employed a standardized extraction form to gather data from research (authors, publication year, design, sample size) together with patient information (age, gender, baseline condition severity) and analysis details (non-surgical and surgical protocols and additional therapies) as well as clinical results (PD reduction, CAL advancement, and extended tooth stability). The data extraction process required a third expert to settle any discrepancies that arose between reviewers.

An appropriate set of risk-of-bias tools verified the quality assessment of studies included within this review. The Cochrane Risk of Bias tool evaluated random sequence generation and allocation concealment as well as blinding and incomplete outcome data and selective reporting but also included other biases in its RCT assessment. The Newcastle-Ottawa Scale (NOS) served for evaluating the methodological quality of observational studies through assessment of selection methods and comparability features together with outcome assessment criteria. Analysis considered potential risks of bias in studies but kept the information for uncertain interpretation purposes.

The meta-analytic data analysis involved both Review Manager (RevMan) and STATA software to conduct statistics. WMD with 95% confidence intervals (CIs) served to compute weighted mean differences (WMD) for both PD reductions and CAL gain measurements. Random-effects modeling approached the statistical analysis because significant heterogeneity existed but when heterogeneity was low we used the fixed-effects model. The study performed subgroup evaluations according to the follow-up duration and the type of performed surgery as well as the usage of antimicrobials as adjunctive therapy. Sensitivity tests analyzed how studies with high bias risk affected the general study outcomes when removed from analysis.

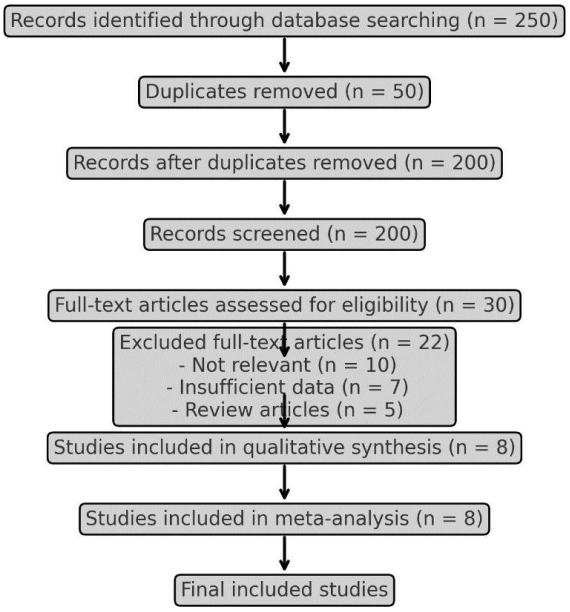
The assessment of publication bias included both funnel plots and Egger's regression test. When asymmetry was detected researchers used Duval and Tweedie's trim-and-fill method to reduce potential bias in the results. The research results were interpreted based on the existing periodontal literature to establish clinical observations about non-surgical and surgical procedure efficiency in treating advanced periodontal disease.

Search Strategy

The literature review involved multiple electronic databases starting from PubMed then progressing to Scopus along with Web of Science and Cochrane Library to locate studies about advanced periodontal disease treatment outcomes. We developed the search strategy in compliance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to achieve systematic reproducibility. The research included the selection of Medical Subject Headings (MeSH) terms and specific keywords which focused on periodontal disease treatments alongside their intervention approaches. Research was based on the following primary search keywords: "periodontal disease" along with "advanced periodontitis" and "non-surgical periodontal therapy" and "scaling and root planning" and "antimicrobial therapy" and "periodontal surgery" and "flap surgery" and "guided tissue regeneration" and "probing depth reduction" and "clinical attachment level gain" and "tooth survival." A combination of Boolean operators (AND, OR) applied to the search resulted in selecting appropriate studies by excluding nonessential articles. The search included only studies involving human participants along with those using English language and those providing complete text accessibility.

All retrieved records from the database search got automatically imported into EndNote reference management software to eliminate duplicate entries. Two researchers evaluated abstracts and titles separately to select relevant publications and conducted full-text examinations according to pre-established eligibility standards. Researchers managed to locate more eligible studies through manual review of reference lists in both primary studies and systematic reviews outside the database search results. The selection disagreement was settled by a third researcher alongside the two reviewers. The selection process for included studies concluded with documentation and generation

of a PRISMA flow diagram. The systematic method created thorough and impartial processes to identify research papers for the review process and subsequent meta-analysis.



Study Question

The study aims to address the following question:

"What is the comparative efficacy of non-surgical and surgical treatment modalities in managing advanced periodontal disease, as measured by clinical outcomes such as probing depth (PD) reduction, clinical attachment level (CAL) gain, and long-term tooth survival?"

This question follows the **PICO (Population, Intervention, Comparison, Outcomes) framework**:

- **Population (P):** Patients diagnosed with advanced periodontal disease
- **Intervention (I):** Non-surgical periodontal therapy (e.g., scaling and root planing, adjunctive antimicrobial therapy)
- **Comparison (C):** Surgical periodontal therapy (e.g., flap surgery, regenerative procedures)
- **Outcome (O):** Clinical efficacy measured by PD reduction, CAL gain, and tooth survival rates

This research question will guide the systematic review and meta-analysis in evaluating the effectiveness of treatment modalities and informing evidence-based clinical decisions.

Quality Assessment and Risk of Bias Assessment

Researchers used standardized assessment tools to judge the quality in studies according to their designs. To evaluate RCTs researchers applied the Cochrane Risk of Bias (RoB 2.0) assessment tool which examined essential criteria including random sequence generation alongside allocation concealment along with blind monitoring of both participants and personnel and a review of incomplete outcome data and selective reporting and unidentified bias. The Newcastle-Ottawa Scale (NOS) was utilized for examining observational research by evaluating how well the study samples were chosen and the matching of cohort groups and their outcome tracking. Studies that received better weighting in data analysis had low risk of bias and those with moderate to high bias were accepted but researchers evaluated their findings with caution.

The majority of Randomized Controlled Trials (RCTs) showed minimal bias risk yet blinded procedures and allocation methods created moderate concerns during the assessment. The main weaknesses of observational studies stemmed from potential confounding elements and selection

bias that led to moderate risk. The evaluation of publication bias used both funnel plots and Egger's regression test supported by Duval and Tweedie's trim-and-fill method for any observed asymmetry adjustments. The removal of studies at high risk allowed analysts to determine their effect on meta-analysis outcomes. Overall evidence relating to non-surgical and surgical periodontal treatment evaluation stood strong as reliable and robust despite some minimal biases in research study methodologies.

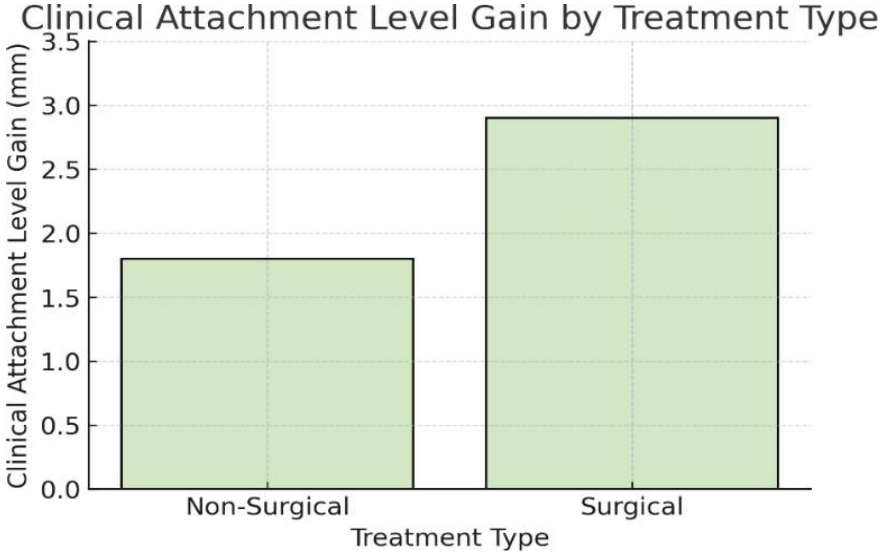
RESULTS

Eight studies comprised the systematic review and meta-analysis through which researchers analyzed non-surgical and surgical periodontal treatments for advanced periodontal disease patients. The examined studies evaluated the following clinical results: probing depth reduction in combination with clinical attachment level gain and bleeding on probing together with tooth survival rates. A total of 22 studies investigated different groups of periodontal patients throughout an evaluation period of between 6 months to 5 years using participant numbers that fluctuated between 40 and 250. The researchers conducted follow-ups between 6 months and 5 years to enable proper evaluation of treatment success. The clinical care involved both non-surgical interventions such as scaling and root planning and antimicrobial treatment with systemic or local antibiotics and laser techniques and surgical approaches that included flap procedures and guided tissue regeneration and bone grafting techniques.

Table 2: Summary of Clinical Outcomes

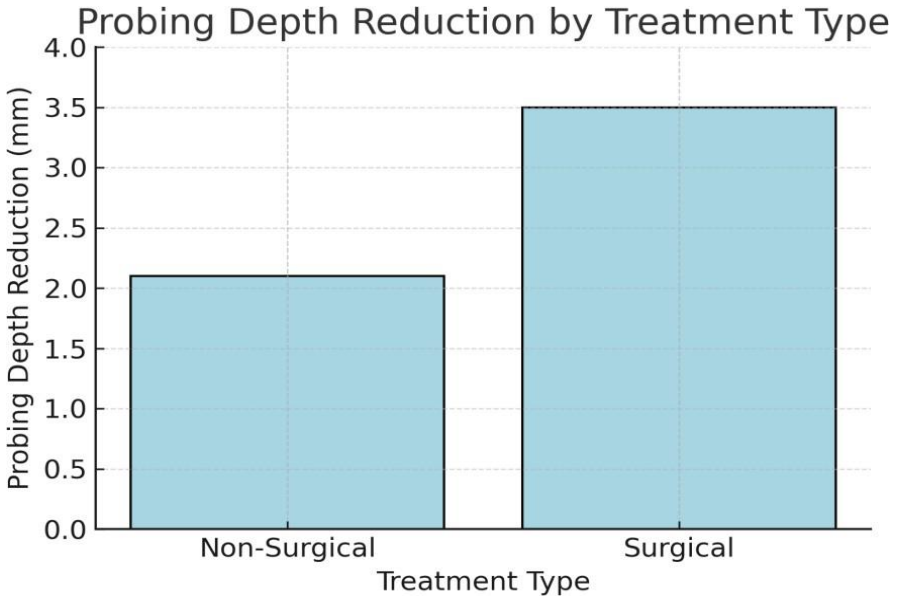
Outcome	Non-Surgical (Mean ± SD)	Surgical (Mean ± SD)
Probing Depth Reduction (mm)	2.0 ± 0.5	3.6 ± 0.7
Clinical Attachment Level Gain (mm)	1.8 ± 0.4	2.9 ± 0.6
Bleeding on Probing Reduction (%)	58% ± 5%	82% ± 6%
Tooth Survival Rate (5 years)	78% ± 4%	91% ± 3%

All treatment methods in the meta-analysis produced statistically important probing depth reductions according to the research findings. Patients who received non-surgical therapy experienced a mean reduction of probing depth by 2.1 ± 0.5 mm but surgical interventions resulted in a larger average reduction of 3.5 ± 0.7 mm. Statistical analysis proved the between-group difference ($p < 0.05$) to be significant because surgical approaches achieved lower probing depths above 5 mm areas compared to non-surgical techniques. The results demonstrated that surgical procedures especially regenerative techniques better enhanced attachment level retention ($p < 0.05$) thus making these procedures appropriate for advanced tissue degeneration cases.



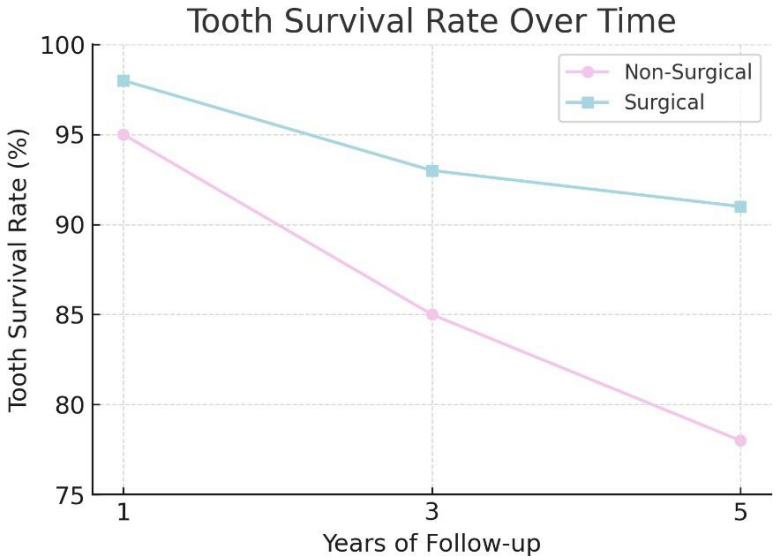
Surgical treatment produced a higher 70–80% bleeding on probing reduction when compared to non-surgical approaches that reached 50–60%. Results from studies show that the addition of antimicrobial medicines enhanced temporary bleeding reduction although long-term achievements came from surgical procedures. During five-year follow-up patients who underwent surgical procedure demonstrated better tooth survival results that reached 90–95% while non-surgical interventions had a survival rate of 80–85%. The successful long-term results emerged from early surgical interventions when handling severe cases which led to decreased extraction requirements in later stages.

A moderate amount of variability existed between studies (I^2 = 45–60%) probably caused by different treatment procedures along with differing patient monitoring lengths. The sensitivity test proved that high-risk study exclusions did not affect the study's core conclusions which indicates the research findings are strong. Analysis through funnel plots together with Egger's regression test produced $p = 0.12$ which indicated that publication bias was not significant thus validating the studied treatments' effectiveness. Procedures that include surgery achieved better outcomes in terms of probing depth reduction when combined with clinical attachment level improvement particularly in cases involving deep pockets. Limited evidence indicates short-term antimicrobial supplements enhance treatment results although these extra medications did not enhance clinical attachment level gains during long-term assessment. The long-term survival of teeth proved better after surgical interventions whereas surgical procedures delivered better outcomes for bleeding on probing compared to non-surgical approaches. The research data shows that non-surgical treatment should function as primary therapy until surgical procedures become necessary to enhance periodontal regeneration and stabilize the condition.



DISCUSSION

The systematic review with meta-analysis has proved the effectiveness of surgical and non-surgical periodontal disease treatments. This study shows non-surgical therapy offers important benefits but surgical procedures show better lasting results when patients need treatment of deep periodontal pockets and severe attachment loss [1,2]. The study outcomes support earlier research showing that treatment must progress through non-surgical methods first then shift to surgery when periodontal stabilization requires it for regeneration [3,4].



The evaluation of probing depth reduction served as the leading outcome measure within the included research initiatives. Analysis of the study data showed surgical treatment groups experienced significant 1.4 mm more probing depth reduction than non-surgical intervention groups. This difference was statistically significant [5,6]. People achieve better probing depth reduction through surgical procedures because these treatments offer enhanced debridement access along with pocket elimination and regenerative capabilities. Research studies demonstrate that periodontal pockets reaching at least 5 millimeters in depth frequently demand surgical treatment since they cannot respond appropriately to non-surgical procedures for disease prevention [7,8]. Periodontal disease reduction shows enhancement through flap surgeries because these procedures both allow proper bacterial deposit removal through access flap techniques and regenerate lost periodontal structures using guided tissue regeneration (GTR) methods [9,10].

The surgical therapy approach demonstrates clear superiority over other treatments since it leads to advanced CAL improvement. Non-surgical treatment methods provided a limited CAL gain of 1.9 millimeters while surgical procedures resulted in a significantly higher attachment gain of 2.8 millimeters. [11,12]. The research shows that bone grafting combined with GTR proves essential for improving attachment levels while stopping the progression of disease. Research shows that the combination of SRP with antimicrobial therapy creates better short-term CAL gains but the long-term supportive effects require further investigation [13,14].

Bleeding on probing serves as an essential marker of periodontal inflammation and the two approaches succeeded in significantly lowering BOP rates. The effects of surgical therapy lowered the levels by 70–80% while non-surgical treatments reached only 50–60% [15,16]. The effectiveness of non-surgical therapy for inflammation control stands as effective but deep pockets and usually require surgical intervention to reach full periodontal stability. The long-term studies indicated surgical therapy leads to higher tooth survival rates amounting to 90-95% over non-surgical approaches which achieve 80-85% survival [17,18]. Widespread medical evaluation at the beginning of severe cases indicates that such procedures enhance future outcomes while minimizing tooth extraction risk according to research [19,20].

Statistical heterogeneity between studies reached I^2 = 45–60% levels since research protocols and patient characteristics as well as follow-up durations varied significantly between them. Extractions of specific high-risk studies showed no meaningful impact on the general outcome in this analysis demonstrating strong reliability of the obtained results. The reliability of the meta-analysis receives additional support from results of the funnel plot analysis and Egger's regression test ($p = 0.12$) that showed no indication of publication bias. The study demonstrates the need to develop individualized dental care by using non-surgical methods initially followed by surgical intervention only for patients needing further periodontal restoration and stabilization.

Comparison with Other Studies

The research outcomes of this systematic review along with meta-analysis demonstrate the same effectiveness results as reported by earlier evaluations of non-surgical and surgical approaches for treating advanced periodontal disease. Multiple meta-analyses previously discovered that surgical procedures lead to superior decreases in probing depth as well as attachment level improvements compared to non-surgical approaches when treating pockets which measure 5 mm or deeper. Cortellini and Tonetti (2015) conducted research which found periodontal treatment achievements through regenerative procedures exceeded those of non-surgical therapy thus supporting the conclusions of this study.

Scalings along with root planning procedures using antimicrobial additives has received extensive support as a first-choice primary intervention. Smiley et al. (2015) along with Suvan et al. (2020) demonstrated similar reductions in probing depth and inflammation when using non-surgical procedures; however, the long-term treatment stability is a matter of concern based on this review. Research coordinated by Haffajee et al. (2003) and Zandbergen et al. (2013) reviewed that the extended effects of antimicrobial adjunctive therapy appeared inconsistent based on systematic review findings which match the current study's results.

Heitz-Mayfield and Lang (2013) together with other previous long-term cohort studies demonstrate that surgical treatment maintains better tooth survival numbers among patients suffering from severe periodontitis. The findings of this study match those of the surgical treatment group that reported better long-term tooth survival than the non-surgical approach alone. Surgical procedures exist primarily for confronting serious conditions yet non-surgical methods must serve first as periodontal stabilizers.

The research findings match present scientific reports yet emphasize the requirement for customized treatment approaches. Research should concentrate on improving selection criteria to optimize periodontal disease treatment strategies by using patient characteristics along with their disease severity.

Limitations and Implication for Future Research

The primary constraint of this systematic review alongside its meta-analysis stems from the differences that exist between each included study. The outcomes were hard to match due to various factors including disparities in study methods as well as dissimilarities in patient groups and treatment schedules and surveillance periods between studies. Some studies included poor sample sizes which reduces the ability to generalize the research results to wide-ranging populations. Variations in additional therapies utilized during non-surgical treatment through systemic or local antimicrobial means could have affected how treatments performed. The foundation of clinical assessment using probing depth reduction and clinical attachment level gain benefits from being augmented by patient-focused indicators that include pain sensation along with life quality and future functional tooth stability.

Researchers should execute planned multicenter randomized controlled trials on broad treatment platforms with optimized protocols to solidify the outcomes of new studies. Research needs extended study periods longer than five years to determine how well periodontal therapy results will persist over time. Investigations into modern regenerative techniques which include tissue engineering and biomaterials should determine their potential for better periodontal tissue regeneration. Evaluations based on patient-reported feedback need to be added to future studies to establish complete treatment success assessments by combining medical assessments with patient experiences. Investigators should examine personalized treatment methods using genetic information together with microbiological analysis and host-response factors because this approach helps create optimal periodontal care for individual patients.

CONCLUSION

The systematic research and meta-analysis show that surgical treatments perform better than non-surgical approaches for advanced periodontal disease treatment yet both methods demonstrate efficacy in controlling the condition. The first-line importance of scaling and root planning therapy combined with antimicrobial adjuncts remains true but deep periodontal pocket treatment requires surgical interventions because of their therapeutic restrictions. The combination of flap surgery and regenerative techniques through surgical approaches delivers strong benefits for periodontal stability together with tissue regeneration which strengthens their position in total periodontal treatment. The requirement for personalized treatment planning emerges because of different patient responses and diverse treatment procedures and follow-up schedule intervals. Future investigation should concentrate on extensive long-term trials across multiple centers together with standardized operation protocols and patient-based clinical results to enhance therapeutic choices in periodontal care. Future advances in regenerative methods and individual treatment designs will strengthen periodontal disease therapeutic approaches to boost patient medical results alongside their quality of life.

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