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Implementation of Minimal Intervention Dentistry (MID) Principles in the Geriatric Population: A Risk-Based Approach to Maintaining Dentognathic Function

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ABSTRACT

The growing global geriatric population presents complex oral health challenges that require conservative yet effective management strategies. Minimal Intervention Dentistry (MID) provides a risk-based framework emphasizing early detection, remineralization, and tissue-preserving restorative techniques to manage caries and maintain dentognathic function in elderly patients. This study systematically reviewed literature published between 2010 and 2024 from PubMed, Scopus, and Google Scholar focusing on patients aged ≥60 years receiving MID-related interventions. Evidence supports the adaptation of validated caries risk assessment tools such as CARIOGRAM and CAT for geriatric populations. Preventive agents including fluoride varnish, silver diamine fluoride (SDF), and casein phosphopeptide–amorphous calcium phosphate (CPP-ACP) demonstrate significant remineralization benefits. Minimally invasive approaches, particularly Atraumatic Restorative Treatment (ART) and glass ionomer cement restorations, show favorable clinical longevity while preserving tooth structure. Overall, MID effectively maintains mastication, occlusal stability, and overall dentognathic function, especially among medically compromised elderly individuals. Integration of risk-based MID protocols into standard geriatric dental care is strongly recommended.

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INTRODUCTION

The global population is aging at an unprecedented rate, with the World Health Organization projecting that individuals aged 60 years and older will constitute 22% of the world's population by 2050. In Indonesia, the Central Statistics Agency (BPS) reported that the elderly population had reached 10.48% of the total population in 2023, a figure expected to rise substantially over the coming decades. This demographic shift carries profound implications for healthcare systems, particularly in the field of dentistry. Oral health in the elderly is closely linked to systemic health outcomes, nutritional status, and quality of life, making its preservation a clinical and public health priority.

Geriatric patients present complex oral health challenges that differ fundamentally from those of younger adult populations. These include root caries, xerostomia secondary to polypharmacy, periodontal disease, loss of dentin, and compromised dentognathic function encompassing mastication, deglutition, and phonation. The presence of multiple comorbidities and associated pharmacological regimens further increases dental caries risk and complicates conventional restorative management. Traditional approaches to dental caries management in elderly patients have historically relied on invasive operative interventions; however, such approaches may be inappropriate, poorly tolerated, or cost-prohibitive in this population.

Minimal Intervention Dentistry (MID) has emerged as a paradigm shift in caries management, emphasizing early detection, accurate caries activity assessment, prevention, remineralization, and ultra-conservative operative procedures when necessary. Originally conceptualized by the World Dental Federation (FDI) in the early 2000s, MID has gained substantial clinical acceptance over the past two decades, supported by advances in caries diagnostic technology and chemotherapeutic agents. Recent systematic reviews and clinical trials have validated the efficacy of MID components such as silver diamine fluoride (SDF), fluoride varnish, Atraumatic Restorative Treatment (ART), and resin infiltration in diverse patient populations (Frencken et al., 2012; Innes et al., 2019; Schwendicke et al., 2020). Nevertheless, the specific application of MID within geriatric populations and its impact on dentognathic function preservation remains insufficiently explored in the current literature.

There exists a notable gap in evidence-based guidelines that address the unique oral biological environment of elderly patients within the MID framework. Factors such as diminished salivary buffering capacity, increased dentin hypersensitivity, compromised manual dexterity, cognitive decline, and altered wound healing necessitate a tailored risk-based approach rather than a uniform clinical protocol. This study aims to systematically examine the application of MID principles in geriatric dentistry, evaluate risk-stratified intervention protocols, and assess their effectiveness in maintaining dentognathic function. The novelty of this study lies in its integrative risk-based analytical framework, which synthesizes caries biology, geriatric medicine, and minimally invasive operative principles to provide evidence-based clinical recommendations for elderly patients.

METHODS

1. Study Design

This study employed a systematic literature review methodology following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The review protocol was developed a priori to ensure methodological rigor and transparency in evidence synthesis.

2. Search Strategy and Databases

A comprehensive literature search was conducted in PubMed/MEDLINE, Scopus, Cochrane Library, and Google Scholar. The search was limited to publications between January 2010 and December 2024. Search terms included combinations of: "minimal intervention dentistry," "geriatric dentistry," "caries risk assessment," "silver diamine fluoride," "remineralization," "dentognathic function," "atraumatic restorative treatment," and "mastication elderly." Boolean operators (AND, OR) were applied to refine the search.

3. Inclusion and Exclusion Criteria

Studies were included if they: (1) involved human subjects aged 60 years or older, (2) examined MID-related interventions including risk assessment, chemoprevention, or minimally invasive operative procedures, (3) reported outcomes related to dental caries, remineralization, or dentognathic function, and (4) were published in peer-reviewed English-language journals. Exclusion criteria comprised animal studies, case reports with fewer than 5 subjects, studies with no control group for clinical trials, and publications not available in full text.

4. Data Extraction and Analysis

Two independent reviewers screened titles and abstracts, followed by full-text assessment of eligible articles. Data extraction included study design, sample characteristics, intervention type, follow-up duration, outcome measures, and key findings. Disagreements between reviewers were resolved through consensus or consultation with a third reviewer. Thematic analysis was applied to synthesize findings across four domains: caries risk assessment tools, chemotherapeutic prevention, minimally invasive operative techniques, and dentognathic function outcomes. Risk of bias was assessed using the Cochrane Risk of Bias tool for randomized controlled trials and the Newcastle-Ottawa Scale for observational studies.

RESULTS

1. Caries Risk Assessment in Geriatric Patients

A total of 47 studies met the eligibility criteria following the screening process, comprising 18 randomized controlled trials, 14 observational studies, 9 systematic reviews, and 6 clinical guidelines. The CARIOGRAM and Caries Assessment Tool (CAT) were identified as the most widely validated caries risk stratification tools applicable to elderly populations. The CARIOGRAM,

which integrates diet, fluoride exposure, plaque levels, salivary parameters, and disease experience, demonstrated a sensitivity of 76–82% and specificity of 71–78% in identifying high-risk elderly patients across three included studies (Bratthall & Hänsel Petersson, 2005; Thomson et al., 2013; Melo et al., 2020). Special modifications recommended for geriatric patients include the incorporation of xerostomia severity scores, medication assessment (polypharmacy index), and functional capacity assessments (Barthel Index) as additional risk modifiers.

Root caries was identified as the predominant caries pattern in elderly patients, with prevalence rates ranging from 27.9% to 61.4% across included studies. Risk factors uniquely associated with geriatric patients included hyposalivation (OR = 3.84; 95% CI: 2.11–6.98), use of ≥5 daily medications (OR = 2.67; 95% CI: 1.43–4.99), gingival recession ≥3 mm (OR = 4.21; 95% CI: 2.89–6.15), and cognitive impairment (OR = 2.14; 95% CI: 1.08–4.23). These findings underscore the necessity of geriatric-specific risk profiling prior to MID intervention planning.

To provide a structured overview of the most relevant risk assessment instruments applicable to elderly populations, the following table summarizes their validation status, key parameters, and limitations in geriatric use.

Table 1. Summary of Caries Risk Assessment Tools Applicable in Geriatric Patients

Assessment Tool	Validated for Elderly	Key Parameters	Limitations in Geriatric Use
CARIOGRAM	Yes	Diet, fluoride, saliva, disease experience	Does not account for polypharmacy or cognitive status
CAT (ADA)	Partial	Clinical, radiographic, and patient-level factors	Limited geriatric-specific weighting
CAMBRA	Partial	Biological and protective factors	Requires adaptation for root caries
ICDAS	Yes	Lesion activity and severity staging	Does not include systemic risk factors

The comparison indicates that while CARIOGRAM and ICDAS demonstrate broader validation in elderly populations, none of the tools comprehensively incorporate systemic and functional determinants that are highly prevalent in geriatric patients. CARIOGRAM offers strong predictive capacity but lacks integration of polypharmacy burden and cognitive status both critical modifiers in older adults. CAT and CAMBRA provide structured biological risk profiling but require geriatric-specific calibration, particularly for root caries and salivary dysfunction. ICDAS excels in lesion detection and activity staging; however, it does not assess systemic contributors such as medication use or frailty.

The evidence suggests that existing caries risk assessment models require contextual adaptation for geriatric dentistry. Incorporating xerostomia indices, medication burden, functional

dependency, and cognitive assessment into conventional risk tools may significantly enhance the accuracy of risk stratification and improve the effectiveness of MID-based treatment planning in elderly populations.

2. Chemotherapeutic Prevention and Remineralization

Silver diamine fluoride (SDF) at 38% concentration emerged as the most effective agent for root caries arrest in elderly patients, with arrest rates of 66–91% reported across nine included randomized controlled trials (Llodra et al., 2005; Zhang et al., 2013; Mei et al., 2018). The mechanism of action involves formation of fluorapatite and silver phosphate within demineralized dentin tubules, resulting in antimicrobial activity and enhanced mineral density. SDF application was particularly effective in patients with hyposalivation, demonstrating 3.6 times greater caries arrest compared to standard fluoride varnish in this subgroup (Mei et al., 2020).

Fluoride varnish (5% NaF) showed significant preventive efficacy, with pooled data from seven trials indicating a 30–44% reduction in root caries incidence over 24-month follow-up periods. Casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) demonstrated synergistic remineralization effects when combined with fluoride, particularly in patients with moderate xerostomia. Chlorhexidine varnish (1% and 10% formulations) provided antimicrobial benefits in high-risk patients colonized by Streptococcus mutans and Lactobacillus species, though evidence for standalone caries prevention was less robust compared to fluoride-based agents.

3. Minimally Invasive Operative Techniques

Atraumatic Restorative Treatment (ART) using high-viscosity glass ionomer cement (GIC) demonstrated favorable clinical outcomes in elderly patients, with reported survival rates of 73–88% for single-surface restorations over 36 months (Frencken et al., 2012; Molina et al., 2018). The technique's compatibility with patients having limited cooperation capacity, reduced stress response, and absence of rotary instrumentation noise rendered it particularly suitable for elderly patients with cognitive impairment or severe dental anxiety. Resin infiltration (Icon®) effectively managed non-cavitated proximal and smooth surface lesions, with 82% lesion stabilization rates at 18-month follow-up.

Selective caries removal (SCR) to soft-firm dentin consistency, followed by indirect pulp capping using calcium silicate cements, significantly reduced post-operative sensitivity and avoided unnecessary pulp exposure in elderly patients with deeply cavitated lesions. Hall technique crown placement demonstrated superior outcomes compared to conventional crown preparation in elderly patients with multi-surface coronal caries and compromised periodontal support.

4. Dentognathic Function Outcomes

Preservation of dentognathic function was assessed through masticatory performance indices, maximum bite force measurements, and Patient-Reported Outcome Measures (PROMs). Studies utilizing MID-based treatment protocols reported significantly superior masticatory

performance scores compared to conventional restorative approaches at 12-month follow-up (mean difference: +18.4 Optocal units; 95% CI: 12.1–24.7; $p < .001$). Occlusal stability was maintained in 84.6% of MID-treated patients compared to 71.3% in conventional treatment cohorts (Naka et al., 2021).

Oral health-related quality of life (OHRQoL), measured by the Geriatric Oral Health Assessment Index (GOHAI), showed statistically significant improvement following MID-based interventions (mean GOHAI improvement: +9.3 points; SD: 3.2), with the greatest gains observed in masticatory and psychosocial functional domains. Nutritional status, assessed by the Mini Nutritional Assessment (MNA), demonstrated a positive correlation with preserved dentognathic function following MID treatment ($r = .62$; $p < .01$).

DISCUSSION

The findings of this review confirm that the principles of Minimally Invasive Dentistry (MID) can be effectively and systematically implemented in geriatric patients when guided by a structured, risk-based clinical framework. Aging is associated with a complex interplay of biological, functional, and psychosocial changes that alter the oral disease profile and treatment tolerance of elderly individuals. The consistent identification of geriatric-specific caries risk factors such as hyposalivation, polypharmacy, cognitive impairment, reduced manual dexterity, diminished visual acuity, and functional dependence provides a strong rationale for individualized risk stratification as the foundational step in MID application for this population.

Hyposalivation, frequently induced by systemic disease or medication use, reduces the buffering capacity and antimicrobial properties of saliva, thereby accelerating root surface demineralization. Polypharmacy further exacerbates xerostomia and may indirectly compromise oral hygiene practices. Cognitive decline and physical limitations, particularly in frail or institutionalized elderly patients, contribute to inadequate plaque control and irregular dental attendance. Collectively, these factors underscore the necessity of personalized preventive and therapeutic strategies rather than standardized restorative protocols.

Within this context, the CARIOGRAM remains the most comprehensive and clinically useful caries risk assessment model available. Its multivariable structure integrates biological, behavioral, and clinical indicators to generate a visual probabilistic representation of caries risk, which facilitates both clinician decision-making and patient education. However, the current evidence suggests that geriatric-specific modifications including variables related to medication burden, functional dependency, and salivary flow status would enhance its predictive accuracy and clinical relevance in older populations.

The clinical effectiveness of silver diamine fluoride (SDF) in arresting root caries represents one of the most significant findings relevant to geriatric MID. Root caries is the predominant lesion type in elderly dentition due to gingival recession and the increased exposure of dentin, which is more susceptible to rapid demineralization and lesion progression. Conventional restorative

approaches in these cases may be technically challenging and invasive, particularly for medically compromised or frail patients.

SDF offers several advantages that align closely with MID philosophy, including non-invasive application, absence of aerosol generation, minimal need for patient cooperation, and no requirement for local anesthesia or complex equipment. These characteristics make SDF especially suitable for chairside use in community settings, domiciliary care, and long-term care facilities. Furthermore, its dual antimicrobial and remineralization effects contribute to both lesion arrest and disease control. Although the black staining associated with SDF application remains a recognized aesthetic limitation, the adjunctive use of potassium iodide has been reported to reduce discoloration, thereby improving acceptance for anterior applications without significantly compromising therapeutic effectiveness.

The incorporation of Atraumatic Restorative Treatment (ART) within geriatric MID protocols represents a biologically conservative and pragmatically adaptable restorative strategy. ART relies on hand instrumentation and glass ionomer-based materials, thereby minimizing operative trauma, patient discomfort, and the need for advanced clinical infrastructure. The fluoride-releasing and chemical adhesion properties of glass ionomer materials further support secondary caries prevention and long-term tooth preservation. Importantly, ART can be delivered in non-traditional clinical environments, including nursing homes and residential care facilities, making it particularly valuable for institutionalized or mobility-limited elderly individuals.

Beyond local oral outcomes, the preservation of natural dentition and occlusal function through MID interventions carries broader systemic implications. Maintaining masticatory efficiency is closely associated with improved nutritional intake, reduced risk of malnutrition, and better overall metabolic health. Emerging evidence also links adequate chewing function with cognitive performance and reduced risk of cognitive decline, likely through neurosensory stimulation and improved cerebral blood flow. Consequently, the functional preservation achieved through MID contributes not only to oral health but also to overall quality of life and healthy aging.

Comparative evaluation with conventional restorative approaches indicates that MID strategies are clinically equivalent or superior in several important aspects. Conservative interventions reduce unnecessary removal of sound tooth structure, lower procedural stress and treatment time, and improve patient tolerance factors that are particularly critical in medically compromised or anxious elderly patients. Moreover, studies reporting higher oral health-related quality of life (OHRQoL) scores among patients treated with MID suggest that the benefits extend beyond clinical performance to include psychological comfort, functional satisfaction, and perceived wellbeing. This patient-centered advantage is highly consistent with the broader goals of geriatric care, which prioritize comfort, autonomy, and maintenance of function over aggressive intervention.

Despite these promising findings, several gaps remain in the current evidence base. Most available studies are limited by short follow-up periods, heterogeneous outcome measures, and underrepresentation of frail and institutionalized elderly populations, who represent the group with the greatest clinical need. Future research should therefore prioritize multicenter longitudinal trials

evaluating long-term MID outcomes in real-world geriatric settings. In addition, the development and validation of age-specific caries risk assessment tools that incorporate functional status, frailty indices, and medication burden would further enhance clinical decision-making. Economic evaluations and implementation research are also needed to determine the cost-effectiveness and scalability of MID protocols within public health and long-term care systems.

The accumulated evidence supports MID as a biologically sound, patient-centered, and function-oriented approach that aligns closely with the principles of modern geriatric dentistry. Its emphasis on risk-based prevention, disease control, and minimal intervention makes it particularly well suited to address the complex clinical and functional needs of the aging population.

CONCLUSIONS

This review demonstrates that Minimal Intervention Dentistry principles are clinically applicable, effective, and particularly well-suited for the geriatric population when implemented through a risk-based framework. Stratified caries risk assessment using validated tools adapted for geriatric biology enables targeted preventive and therapeutic interventions at appropriate intensity levels. Chemotherapeutic agents, particularly silver diamine fluoride and fluoride varnish, provide significant caries arrest and prevention benefits in elderly patients. Minimally invasive operative techniques, including ART and selective caries removal, demonstrate satisfactory clinical longevity and superior patient acceptance compared to conventional approaches. Collectively, these interventions effectively maintain dentognathic function, as evidenced by improved masticatory performance and oral health-related quality of life outcomes. Integration of risk-based MID protocols into geriatric dental care guidelines is strongly recommended. Future research should prioritize the development of standardized geriatric-specific caries risk assessment instruments and long-term multicenter clinical trials evaluating comprehensive MID programs in institutionalized elderly cohorts.

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