Minimally Invasive Approaches in Caries Management - II

Çürük Yönetiminde Minimal İnvaziv Yaklaşımlar - II

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ABSTRACT This chapter provides a comprehensive overview of the biological and minimally invasive approaches used in caries management for children and adolescents. Chemomechanical caries removal (CMCR) softens infected dentin chemically and enables selective excavation with reduced pain and diminished need for anesthesia. Non-restorative cavity control (NRCC) and interim therapeutic restorations (ITR) suppress lesion activity and serve as transitional strategies until natural exfoliation or definitive restorative treatment is feasible, particularly in patients with limited cooperation or extensive caries. Atraumatic restorative treatment (ART), the Hall Technique, stepwise excavation, and selective caries removal (SCR) are presented as protocols aimed at reducing the risk of pulp exposure, preserving as much sound enamel and dentin as possible, and delaying the restorative cycle. When tailored to appropriate patient and tooth selection, these approaches enable personalized, biologically oriented caries management in pediatric dentistry.

Keywords: Preventive dentistry; dental restoration, permanent; dental restoration, temporary; pain-free; dental anxiety

ÖZET Bu bölümde, çocuk ve genç hastalarda çürük yönetiminde kullanılan biyolojik ve minimal invaziv yaklaşımlar bütüncül olarak ele alınmaktadır. Kemomekanik çürük yönetimi (CMCR), çürük dentinin kimyasal olarak yumuşatılıp el aletleriyle seçici kaldırılmasını sağlayarak ağrıyı ve anestezi ihtiyacını azaltır. Restoratif olmayan kavite kontrolü (NRCC) ve geçici terapötik restorasyon (ITR), özellikle kooperasyonu kısıtlı veya çok yüzeyli çürüğü olan olgularda çürük aktivitesini baskılayıp doğal eksfoliasyon veya ileri restoratif tedaviye kadar köprü tedavi görevi görür. Atravmatik restoratif tedavi (ART), Hall Tekniği (HT), aşamalı çürük temizleme (SW) ve selektif çürük temizleme (SCR); pulpa ekspoz riskini azaltmayı, sağlıklı mine, dentin dokusunun mümkün olduğunca korunmasını ve tekrar restorasyon döngüsünü geciktirmeyi hedefleyen farklı protokoller olarak sunulmaktadır. Bu yaklaşımlar, uygun hasta ve diş seçimiyle kombine edildiğinde, çocuk diş hekimliğinde kişiselleştirilmiş çürük yönetimine olanak tanır.

Anahtar Kelimeler: Koruyucu diş hekimliği; diş restorasyonu, kalıcı; diş restorasyonu, geçici; ağrısız; dental anksiyete

The current definition of caries is "a biofilm-mediated, diet-modulated, multifactorial, non-communicable, dynamic disease" resulting in net mineral loss of dental hard tissues. Contemporary research in cariology has reframed dental caries from a simple infectious disease into a complex, biofilm-driven and diet-modulated condition influenced by behavioral and environmental factors. It is now recognized as a non-communicable disease involving ongoing cycles of mineral loss and repair within the tooth structure.[1] This biologically informed understanding has shifted clinical practice away from traditional surgical restorative methods toward a preventive, tissue-conserving philosophy known as Minimal Intervention Dentistry (MID). MID prioritizes early detection, accurate lesion assessment, individualized risk evaluation, and the selection of the least invasive, biologically appropriate strat-

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egy to preserve tooth vitality and support long-term oral health.[1,2]

Contemporary minimally invasive caries management represents a broad spectrum of approaches that extend from non-operative strategies to micro-invasive and conservative operative procedures. Within this spectrum, non-operative modalities -including non-restorative cavity control (NRCC) and interim therapeutic restorations (ITR)- aim to modify the disease process by disrupting biofilm accumulation, enhancing fluoride exposure, and stabilizing lesions through temporary sealing techniques. Chemomechanical caries removal (CMCR) offers a tissue-preserving method that selectively softens and removes infected dentin, thereby minimizing reliance on rotary instrumentation and often reducing or eliminating the need for local anesthesia. Micro-invasive and operative options -including atraumatic restorative treatment (ART), the biologically oriented Hall Technique, stepwise excavation, and selective caries removal (SCR)- enable clinicians to manage carious lesions while maximizing pulpal vitality and maintaining structural integrity.[3,4]

A substantial body of research supports the effectiveness of these biologically oriented, minimally invasive strategies. Numerous clinical trials report that atraumatic restorative treatment (ART), and the Hall Technique consistently achieve high success and survival outcomes, while also being well tolerated by children, parents, and dental professionals.[5] Importantly, these approaches often lessen the need for pharmacological behavior management, including sedation or general anesthesia, and provide viable options in settings with limited resources-ultimately promoting more equitable and sustainable models of oral healthcare delivery.[6]

Collectively, the integration of CMCR, NRCC, ART, the Hall Technique, stepwise excavation, SCR, and ITR represents the foundation of contemporary, biologically driven caries management. These approaches embody the core principles of MID: preserve tooth structure, control disease biologically, intervene conservatively, and prioritize the child's overall well-being. As the profession continues to move toward prevention-centered, patient-focused dentistry, minimally invasive strategies have become indispensable tools for delivering ethical, effective, and durable pediatric oral health care.[7]

CHEMOMECHANICAL CARIES REMOVAL (CMCR)

Chemomechanical caries removal (CMCR) is a minimally invasive approach in which carious dentin is softened by chemical agents and subsequently removed using hand instruments such as excavators. This technique preserves more sound dentin compared with conventional rotary caries removal, reduces the need for anesthesia, and minimizes the risk of pulpal injury.[8] It offers a painless and anxiety-reducing treatment option, particularly for children, uncooperative individuals, and patients with special healthcare needs.[9]

The clinical application steps of chemomechanical caries removal (CMCR) systems vary according to the specific chemical agent used, yet they generally follow a structured sequence designed to ensure selective removal of infected dentin while preserving sound tissue. As summarized in Table 1, Carisolv®, Papacarie®/Carie-Care™, and BRIX3000® share common procedural phases -including isolation, agent placement, waiting time for dentin softening, mechanical removal with hand instruments, and final cavity assessment- while differing in their recommended application times, instrument requirements, and reapplication needs. Understanding these step-by-step differences is essential for clinicians to optimize treatment efficiency, minimize patient discomfort, and integrate CMCR protocols effectively into minimally invasive dentistry.[8-12]

Despite its advantages, CMCR techniques also have limitations. Procedure time especially when hypochlorite-based products such as Carisolv® are used is significantly longer compared with conventional rotary caries removal[10]. Some agents are relatively costly and may not be available in every clinic.[11] In deep or sclerotic lesions, the effectiveness of tissue softening may decrease, which may require additional mechanical assistance or repeated applications.[11] The pH stability of the agents is dependent on proper isolation, and clinical success requires adequate expertise and operator experience.[13] For agents such as Carisolv®, the use of special curettes is essential to achieve maximum efficiency.[12] Therefore, although CMCR offers important biological advantages, factors such as time, cost, and technique sensitivity may limit its widespread clinical use.[11]

NON-RESTORATIVE CAVITY CONTROL (NRCC)

Non-restorative cavity control (NRCC) is an approach aimed at biologically controlling caries progression without placing any restorative material.[13] In this method, protruding or plaque-retentive enamel or dentin margins that contribute to biofilm accumulation are removed using hand or rotary instruments to make the cavitated lesion cleansable. This is followed by the application of 38% silver diamine fluoride (SDF) solution or 5% sodium fluoride

TABLE 1: Comparative clinical application steps of commonly used chemomechanical caries removal agents [8-12]

Step	Carisolv®	Papacarie® / Carie-Care™	BRIX3000®	Clinical Notes
Isolation	Isolation with cotton rolls or rubber dam; careful isolation required due to the hypochlorite-based gel	Cotton rolls or rubber dam adequate	Cotton rolls or rubber dam adequate	Isolation is essential for agent effectiveness and patient comfort
Application of Agent	Gel is placed into the cavity using a special applicator/spatula	Applied to the cavity surface using a micro-applicator or syringe tip	Applied with a micro-applicator or syringe tip	The entire cavity surface must be adequately covered
Waiting Time	30 sec-1 min	1-3 min	1-2 min	During this period, the gel softens the carious dentin
Mechanical Removal	Softened dentin is removed with special Carisolv® curettes	Gently removed using curettes or hand instruments	Gently removed using curettes or hand instruments	Only the softened necrotic dentin should be removed; sound dentin must be preserved
Reapplication	Gel can be reapplied 2-3 times if necessary	A second application may be performed if needed	Usually sufficient in a single application	Suitable for deep or multi-surface lesions
Cavity Assessment	Visual and tactile hardness assessment	Same hardness/visual assessment	Same hardness/visual assessment	Selective dentin removal is the goal; complete hardness of all dentin is not required
Restoration	GIC or composite; restorative procedures usually follow	GIC/composite or can be combined with an NRCC approach	GIC/composite or can be combined with an NRCC approach	Can be integrated with NRCC and ITR protocols
Procedure Time	Generally longer than papain-based agents	Moderate	Short-comparable to Papacarie®	BRIX3000® applications are among the shortest

(NaF) varnish to the lesion.[14] These agents suppress lesion activity, prevent further progression, and contribute to remineralization.[15]

The success of NRCC largely depends on patient compliance and regular monitoring of lesion progression by the clinician.[13,16] This method is indicated particularly in situations where the aim is to maintain primary teeth in a pain-free and infection-free condition until their natural exfoliation time.[14,17] Because NRCC does not require anesthesia or extensive cavity preparation, it is considered a treatment approach that supports cooperation.[18]

In permanent teeth, NRCC is mostly preferred for managing root-surface and smooth-surface lesions; its purpose is to minimize repeated restorative interventions and preserve long-term tooth function.[19]

In the literature, the number of studies evaluating NRCC in permanent teeth is limited; therefore, the current level of evidence appears weaker compared with other biologically based approaches.[18] Additionally, because treatment success depends greatly on patient motivation and adherence to preventive protocols, NRCC cannot be universally recommended for all types of carious lesions.[19,20] According to contemporary intervention thresholds, NRCC is particularly indicated for cavitated lesions in which biofilm-retentive enamel or dentine can be conservatively removed to regain cleansability -currently limited to primary teeth or root-surface lesions- and, under optimal conditions, it offers a biologically oriented, non-restorative alternative for managing disease progression, especially in uncooperative children or medically compromised older adults.[21]

However, the biological principles underlying the approach are strong; therefore, when applied by clinicians with effective communication and patient-education skills, NRCC can be considered a preventive and follow-up–based alternative for cooperative patients who will comply with regular recall schedules.[22,23]

ATRAUMATIC RESTORATIVE TREATMENT (ART)

The removal of carious tissue using high-speed rotary in-

struments and local anesthesia is often not feasible in developing countries where essential dental equipment and electricity are not always available. For such settings, Atraumatic Restorative Treatment (ART) was developed as a minimally invasive approach to manage dental caries.[24,25] In developed countries, ART principles have also contributed to the use of glass ionomer restorations as Interim Therapeutic Restorations (ITR) to arrest the progression of severe early childhood caries through fluoride release.[24]

In the ART technique, infected dentin is removed using hand instruments -typically without the need for local anesthesia- while affected dentin is intentionally preserved, and a self-adhesive restorative material such as glass ionomer cement (GIC) is placed. Currently, the most widely used materials for ART are glass-hybrid restorative systems and high-viscosity GICs (HVGICs), due to their improved wear resistance, reduced moisture sensitivity, favorable setting times, durability, and good marginal adaptation.[24,25] Fissures adjacent to the restoration, especially those exhibiting enamel demineralization or high caries risk, are also sealed. The ability of GICs to chemically bond to enamel and dentin, their biocompatibility with the pulp, ease of manipulation, fluoride release, and suitability in environments without electricity make them advantageous for ART. By following the principles of selective caries removal, ART also reduces the risk of pulp exposure by avoiding excessive removal of dentin near the pulp.[25] Evidence has shown that sealing affected dentin can arrest lesion progression, and the remaining dentin beneath ART restorations can undergo remineralization.[26] Additionally, ART has been associated with a 22% reduction in bacterial counts following treatment.[27]

Based on current intervention thresholds, ART is particularly indicated for active cavitated dentin lesions that are not cleansable and therefore require restorative intervention, while still allowing a minimally invasive, biologically oriented approach.[21] Indications for ART include patients with special healthcare needs, highly anxious individuals, medically compromised older adults, young children with limited cooperation, and individuals living in areas with limited dental care resources. Suitable lesions are those accessible with hand instruments, with cavitated dentin lesions at least 1.6 mm in width. Conversely, lesions that cannot be reached with hand instruments, as well as teeth presenting with irreversible pulpitis, pulp exposure, abscess, or sinus tract are contraindicated for ART.[25]

While ART shows lower success rates in multi-surface cavities, high survival outcomes have been reported for single-surface restorations in both primary and permanent teeth.[24,25] Survival rates of ART restorations are significantly improved when high-viscosity glass ionomer materials are coated with a nanofilled resin surface sealant.[28] A meta-analysis including both field and clinical studies reported that, regardless of setting, ART achieves higher survival in single-surface cavities compared with multi-surface restorations. In primary teeth, survival for occlusal cavities ranged from 43-97% and 12-84% for multi-surface cavities over 12-36 months. In permanent teeth, survival ranged from 30-97% for occlusal and 41-96% for multi-surface restorations.[29] When ART is performed using improved glass ionomer materials such as HVGICs or glass-hybrid restorations, its clinical performance has been shown to be comparable to composite resin.[29] Furthermore, in a five-year study evaluating restorations placed in individuals with disabilities, ART performed with HVGIC demonstrated superior survival outcomes compared with conventional composite restorations, suggesting ART as a preferable option in this group.[30]

Since ART relies primarily on hand instruments and GIC-based materials, it is less costly than other restorative techniques. It is also less traumatic for the patient and typically does not require local anesthesia. Therefore, ART may be considered an appropriate treatment option for very young or uncooperative children, as well as for patients with special healthcare needs for whom conventional restorative approaches may not be feasible.[24]

HALL TECHNIQUE

The Hall Technique, one of the minimally invasive treatment methods, is applied based on the philosophy of managing primary molars with stainless steel crowns (SSCs) without any caries removal. A representative clinical example of the Hall Technique, including pre-operative assessment, crown placement, and radiographic follow-up, is shown in Figure 1. After cleaning visible debris and food remnants, the crown is cemented with luting glass ionomer cement, thereby sealing the carious lesion and cutting off the carbohydrate supply to the bacteria in dental plaque, which arrests or slows lesion progression until natural exfoliation of the primary tooth. Reactive dentin formation beneath the sealed carious lesion has been observed following treatment.[31] Because the technique does not involve local anesthesia, caries removal, or tooth preparation, it offers high patient comfort and acceptance; therefore, it is particularly suitable for anxious children.[32-34] During clinical application, to prevent the risk of crown aspiration, the child

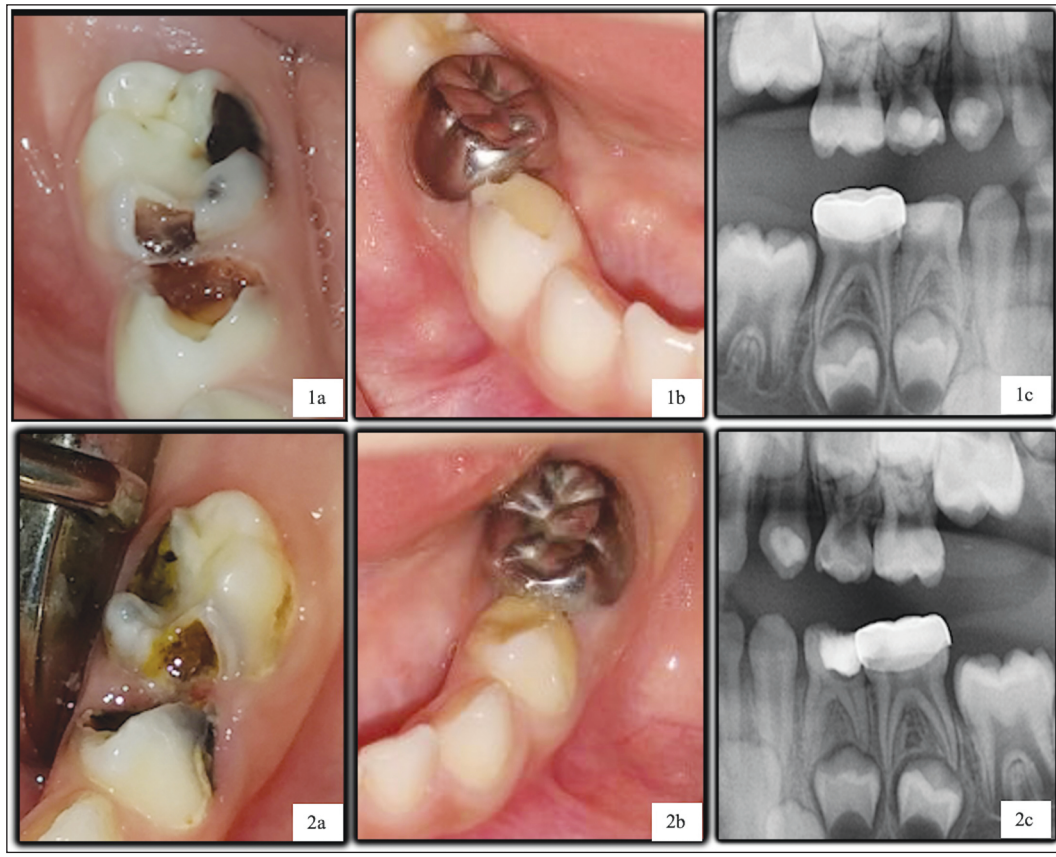

FIGURE 1: Clinical and radiographic images of the Hall Technique
(1a and 2a) Pre-operative occlusal and proximal carious lesion on the primary molar (#85 and #75, respectively). **(1b and 2b)** Stainless steel crown placement without caries removal. **(1c and 2c)** Post-operative radiograph demonstrating successful seal of the carious lesion.

should be seated upright, the crown may be secured with micropore tape, and gauze should be placed between the tongue and teeth. Proper crown selection requires a "spring-back" sensation at the contact points; if the crown is fully seated before cementation, removing it can be difficult.[31]

When tight contacts prevent crown placement, orthodontic elastic separators can be inserted interproximally for 3-5 days to obtain adequate spacing.[34] Midani et al. compared the modified Hall Technique -where minimal reduction of proximal contacts or occlusal cusps is performed without removing caries- to the standard Hall Technique and reported no differences in clinical success between the two methods.[35] Another modification evaluated the effect of diode laser or SDF application prior to cementation; no significant differences in clinical success were found between pre-treated and non-treated groups.[36]

Current evidence-based intervention criteria suggest that the Hall Technique is particularly indicated for active dentin lesions that are cavitated and non-cleansable, where a restorative intervention is required. In such cases, sealing the lesion with a preformed stainless steel crown aligns with the biological rationale of isolating the biofilm and arresting lesion progression without the need for invasive preparation.[21] The Hall Technique is indicated for proximal lesions with or without cavitation, for non-cavitated occlusal lesions when the child refuses conventional treatment, and for cavitated occlusal lesions when conventional or partial caries removal is not accepted by the child. It is contraindicated when clinical or radiographic signs indicate pulpal involvement, when periradicular pathology is present, when pulpitis signs or symptoms exist, when tooth structure is insufficient for SSC retention, when the lesion is self-cleansable and does not require restoration, when the permanent successor is near eruption, and in patients at risk for bacterial endocarditis.[31]

The five-year clinical success of the Hall Technique for multi-surface carious lesions has been reported to exceed 90%. When the three-year survival of ART and the

Hall Technique in multi-surface lesions of primary teeth was compared, ART demonstrated approximately 33% survival, whereas the Hall Technique showed 93% survival.[32] In a split-mouth study comparing the Hall Technique with conventional compomer restorations, five-year survival rates were similar (92% vs. 85%), but the Hall Technique showed significantly higher clinical and radiographic success (85%) without major and minor failure than compomer restorations (23%).[37] The Hall Technique has been reported to demonstrate higher microleakage compared with conventionally placed SSCs.[38] It has also been shown that the increase in occlusal vertical dimension following SSC placement with the Hall Technique returns to baseline within one month due to intrusion of the treated tooth.[32] Additionally, in a 12-month follow-up of children treated with the HT, no significant differences in temporomandibular dysfunction were observed before and after treatment.[39] Furthermore, surface electromyography studies evaluating masseter muscle activity showed that clenching activity decreased immediately after treatment, returned to baseline by two weeks, and exceeded baseline levels by six weeks.[37]

STEPWISE EXCAVATION

According to contemporary intervention thresholds, stepwise excavation is indicated in deep cavitated dentin lesions that require restorative intervention but present a high risk of pulp exposure if complete caries removal is attempted in a single visit. By reducing the bacterial load during the interval period, the technique aligns with the biological rationale of performing restorative treatment in a safer, pulp-preserving manner.[21] With the development of minimally invasive concepts, procedures such as stepwise excavation and selective caries removal were introduced to preserve as much sound tooth structure as possible and to maintain tooth function. In stepwise excavation, part of the carious dentin is removed in the first visit, while a layer of carious dentin close to the pulp is intentionally left to promote remineralization, followed by placement of a temporary restoration. After 6-12 months, the tooth is re-entered, the temporary restoration and remaining carious dentin are removed, and a definitive restoration is placed. The aim of this technique is to minimize pulpal irritation.[40] However, this procedure requires two visits and patient compliance and carries the risk of temporary restoration failure. For these reasons, and with increasing recognition of the importance of effective lesion sealing in arresting caries progression, selective caries removal has become a more widely accepted approach.[2]

According to a systematic review and meta-analysis published in 2020, there is no statistically significant difference between stepwise excavation and selective caries removal in terms of pulpal health.[40] The risk of pulp exposure is highest with non-selective (complete) caries removal, lower with stepwise excavation, and lowest with selective caries removal. Similar levels of bacterial reduction were observed for selective and non-selective techniques, and both techniques demonstrated comparable performance in terms of dentin remineralization and restoration outcomes.[40] In contrast, a Cochrane systematic review reported that stepwise excavation was associated with a significantly higher risk of pulp exposure than complete caries removal in both primary and permanent teeth, while no differences were found between the two techniques in signs or symptoms of pulpal disease during 1-year follow-up.[41] In a randomized controlled trial comparing stepwise excavation with indirect pulp capping in young permanent molars restored with calcium hydroxide and GIC, indirect pulp capping showed a 90% success rate at 6 months, whereas stepwise excavation showed 65%. Moreover, tertiary dentin formation was radiographically evident in 85% of teeth treated with indirect pulp capping compared with 65% in the stepwise excavation group.[42] A retrospective study evaluating 496 permanent molars treated with stepwise excavation reported an overall success rate of 72.3%, with pulp exposure (15.6%) and irreversible pulpitis/apical periodontitis (7.8%) being the most common complications; most failures were attributed to pulpal exposure during re-entry and leakage associated with temporary restorations.[43] In another study evaluating disinfectants used during stepwise excavation in primary molars, bacterial reduction was highest with chlorhexidine (93%), followed by ozone (82%) and the control group (74%); chlorhexidine was therefore suggested as an effective option for one- or two-visit indirect pulp therapy in primary teeth.[44]

Selective caries removal offers several advantages, including being less invasive, having a lower risk of pulp exposure, and eliminating the need for a second visit, making it more time- and cost-efficient. For these reasons, the clinical use of stepwise excavation has become increasingly limited.[2,40]

SELECTIVE CARIES REMOVAL (SCR)

Following the era of traditional Black cavity design, in which carious tissue was removed until sound enamel and dentin were reached (“extension for prevention”), the shift

MID emphasized strategies such as dietary modification, biofilm disruption, and hermetic sealing of cariogenic biofilm to cut off nutritional supply. With emerging evidence, selective caries removal was introduced to avoid unnecessary removal of tooth structure, to reduce the risk of pulp exposure in deep dentin lesions, and to preserve the odontoblastic palisade so that reactionary rather than reparative tertiary dentin is formed.[2] Contemporary biologically oriented intervention concepts recommend SCR for active cavitated dentin lesions that are not cleansable and therefore require restorative intervention, while minimizing the risk of pulp exposure in deep lesions. This threshold-based indication aligns with the biological principle that sealing and preserving affected dentin is sufficient to halt lesion progression without unnecessary removal of tooth structure.[21]

In selective caries removal, all peripheral carious tissue is completely removed, while in the pulpal area only soft dentin that can be removed with a hand excavator is eliminated, leaving affected dentin behind. Although adhesion to affected dentin is weaker, this difference is considered clinically irrelevant as long as restoration margins rest on sound enamel. Figure 2 shows the pre-treatment condition, selective caries removal, restoration, and follow-up of MIH-affected molars treated with glass hybrid and short fiber-reinforced composite materials.[44] For this technique, applying the bonding agent in two layers has been shown to improve adhesion and durability of restorations placed following SCR.[2]

According to the 2013 Cochrane Review, compared with complete caries removal, selective caries removal results in lower risk of pulp exposure, reduced incidence of signs and symptoms of pulpal disease at one year, and fewer restoration failures.[41] Moreover, in molar-incisor hypomineralization (MIH) molars restored after SCR, short-fiber-reinforced composite (SFRC) covered with microhybrid composite demonstrated 3.3-fold higher retention than glass hybrid restorations over two years.[45] At 3-year follow-up, both materials showed similar clinical performance.[46] However, when glass hybrid restorations were placed following selective caries removal in MIH-affected molars, the 6-year survival was reported as 24% in mild MIH and 11% in severe MIH cases.[47]

Although current clinical guidelines recommend selective caries removal as a more conservative and pulp-protective approach, many clinicians still prefer complete caries removal. This preference is attributed to long-standing clinical habits, concerns regarding leaving caries-affected dentin near the pulp, and conceptual misunderstandings.[40]

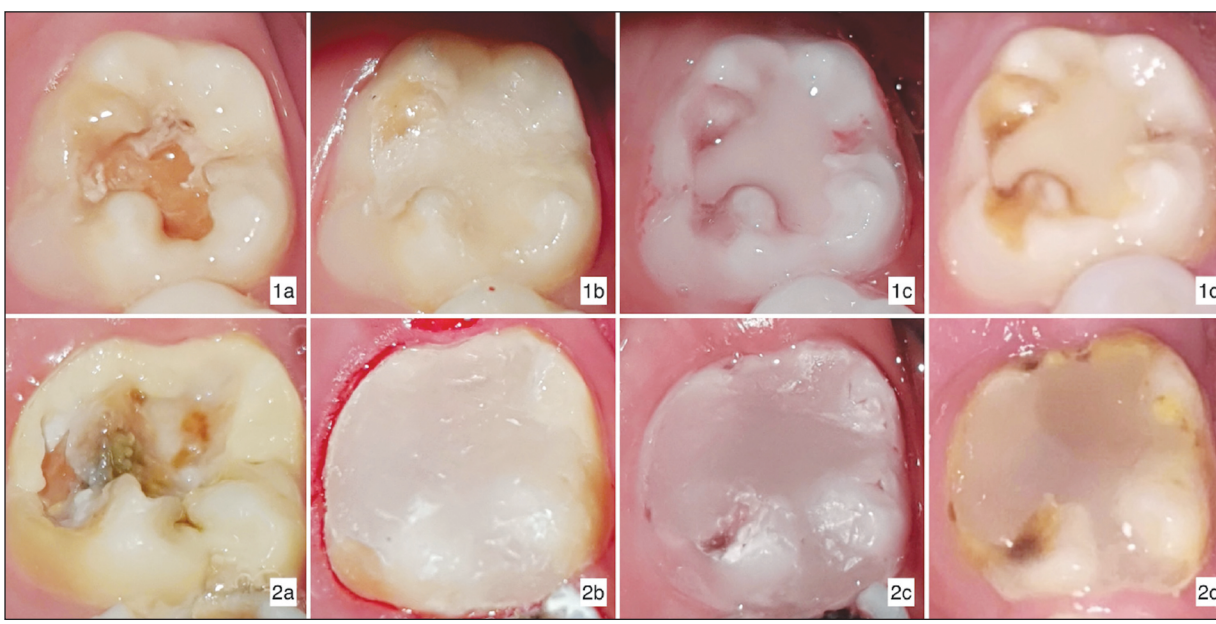

FIGURE 2: Clinical intra-oral photographs illustrating an example of the presentation, selective caries removal, restoration, and follow-up of teeth assigned to group one (1, glass hybrid) and group two (2, short fiber-reinforced composite)
(a) Images show pre-treatment, **(b)** baseline following selective caries removal and restoration, **(c)** 12-and **(d)** 24- month follow-up.

INTERIM THERAPEUTIC RESTORATION (ITR)

Interim therapeutic restoration (ITR) is a minimally invasive restorative approach designed to biologically control caries and make treatment more manageable in children with limited cooperation, high dental anxiety, or special health-care needs.[48] ITR is based on selective removal of infected dentin and filling the cavity with a high-fluoride–releasing GIC, similar to the principles of ART.[49] These features make it a treatment option that provides both restorative function and temporary stabilization at early stages.[48]

This technique is particularly useful when treatment needs to be postponed, when a gradual improvement in cooperation is expected, or when multiple active carious lesions must be controlled.[48] ITR is performed according to minimally invasive principles. First, access to the cavity is gained, and soft, infected dentin is selectively removed using hand excavators or low-speed burs; the aim is not to eliminate all caries but to biologically control the lesion by removing the infected dentin.[48] This approach prevents unnecessary pulpal trauma and, by preserving sound dentin, supports a more conservative restorative cycle.[49] After achieving moisture control, a high-viscosity glass ionomer cement is placed; the fluoride release, chemical bonding, and moisture tolerance of GIC play important roles in the biological success of ITR.[50]

The effect of glass ionomer restorations on caries activity is supported by current clinical evidence. Systematic reviews have shown that high-viscosity GICs used in the ART approach demonstrate high long-term survival rates, particularly in posterior teeth.[50] These data support that GIC materials used in ITR provide similar biological advantages and contribute to controlling caries progression.[50] Therefore, ITR should be considered an active component within comprehensive caries-management protocols rather than a standalone treatment.[49]

ITR is frequently preferred in young children with challenging behavior as a means to reduce caries burden, make clinical sessions more manageable, and progress treatment gradually before the definitive restoration.[48] It is also used for temporary stabilization before procedures performed under sedation or general anesthesia.[49] Based on current minimal intervention principles, ITR is particularly indicated for active cavitated dentin lesions in patients who cannot tolerate conventional restorative procedures, thus providing a minimally invasive and biologically oriented interim solution until definitive treatment can be performed.[21]

Additionally, ITR has been shown to be an effective alternative in low-resource settings where access to rotary instruments is limited, making it one of the practical minimally invasive options for such environments.[50]

CONCLUSION

This chapter summarizes current minimally invasive strategies for managing caries in children and compiles the best available evidence to guide clinical decision-making. While these approaches provide biologically oriented, patient-centered alternatives to traditional restorative care, the strength of evidence varies across techniques. Continued efforts to expand the clinical evidence base will help refine indications and further support the integration of minimally invasive principles into pediatric dental practice.

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