

REVIEW ARTICLE

Smart Burs in Pediatric Dentistry- A Literature Review

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Abstract

Smart burs have gained attention in paediatric dentistry as a minimally invasive alternative for caries removal, aiming to balance biological preservation with clinical efficiency. Unlike conventional carbide burs, which may remove both infected and potentially reparable dentin, smart burs are designed to be more selective, targeting only the softened, irreversibly infected dentin while preserving affected and healthy tissue. This selective action supports the core principles of conservative dentistry, especially in primary teeth, where maintaining tooth structure is essential for pulpal protection and long-term function. Evidence from recent clinical studies suggests that smart burs can improve caries removal selectivity, reduce unnecessary tooth loss, and enhance patient comfort, particularly in children who may benefit from less aggressive treatment approaches. However, their cutting speed may be slower than conventional burs, and operator technique as well as case selection remain important considerations. Overall, smart burs represent a promising adjunct in paediatric restorative care, offering a biologically respectful approach that aligns with modern minimally invasive dentistry while maintaining acceptable clinical effectiveness.

KEYWORDS

Smart burs, Pediatric dentistry, minimally invasive dentistry, Caries removal, Infected dentin

1 | INTRODUCTION

Dental caries is one of the most common chronic diseases of modern times. For the majority of the 20th century, Dr. G.V. Black had a significant impact on operative dentistry. His concept of "Extension for Prevention" was widely accepted. He believed that once caries developed, they would progress until the tooth was lost. This resulted in a mechanistic or surgical approach rather than a biological or therapeutic one¹. Over the last few decades, extensive research in cariology has introduced minimally invasive treatments as an alternative therapy. There has been a shift from the philosophy of "drill and fill" to a minimally invasive approach². G. V Black's seminal statement, "Generally when the cavity has been cut to form no carious dentine should remain," influenced how dentists treated carious lesions for more than 100 years.³ This historical approach to carious lesion management gave little consideration to its effects on pulp vitality or the loss of healthy tooth structure. Rather, carious tissue was treated like gangrenous tissue with its complete surgical excision considered the gold standard. However, even in that era of dentistry, there were opposing views on how much carious tissue should be removed. Sir John Tomes, writing in 1859, suggested that "it is better that a layer of discoloured dentine should be

allowed to remain for the protection of the pulp rather than run the risk of sacrificing the tooth."⁴ However, Black's guidelines encompassing non-selective caries removal and "extension for prevention" remained the bedrock of carious lesion management, taught religiously at dental schools, and practiced faithfully by dentists worldwide. The first philosophical evolution in lesion management principles occurred in the late 1960s and early 1970s based on concurrent research by Fusayama and Massler.^{5,6,7} They described two distinct layers of carious dentine, an outer bacterially contaminated or "infected" zone, and an inner demineralized or "affected" zone. It was suggested that only the bacterially contaminated outer zone needed to be excavated during cavity preparation, leaving behind the inner zone that had remineralization potential. This advice was the genesis of selective carious tissue removal and the first departure from Black's guidelines. Selective caries removal, also known as "minimally invasive" or "conservative" caries removal, takes a more conservative approach to caries management. Instead of removing all decayed tissue, dentists selectively remove only the soft, actively infected dentin, leaving the harder, more mineralized dentin unaffected. The focus is on preserving healthy tooth structure while still removing areas of active caries.⁸

2 | RATIONALE FOR MINIMALLY INVASIVE CARIES MANAGEMENT

Minimally invasive dentistry (MID) has revolutionized pediatric dental care by emphasizing the preservation of healthy tooth structures, reducing treatment-related trauma, and improving patient compliance. Conventional restorative approaches, such as invasive drilling and amalgam fillings, often exacerbate dental anxiety in pediatric patients, contribute to unnecessary removal of healthy tooth structure, and remain inaccessible in resource-limited settings. Conventional methods for the restoration of dental caries may cause distress in patients. To lower the levels of anxiety experienced by children, minimal intervention dentistry principles can be used to minimize dental anxiety⁹. Biological approaches are based on preserving tooth structure and maintaining function for as long as possible and, in the case of primary teeth, until they naturally exfoliate.¹⁰ Conventional burs removed more micro-organisms as they have greater Knoop hardness of 7,000 KHN due to which it has greater cutting efficiency and remove both affected and infected dentin. However, smart burs have a Knoop hardness of 50 KHN, which is higher than carious, softened dentin (0–30 KHN) but is softer than healthy dentin (70–90 KHN), making it efficient in removing only the infected dentin and involuntarily affected dentin is left behind.¹¹ For pediatric dentists, smart burs translate MID principles into actionable technique: they enable selective caries removal in a single visit, reduce procedural anxiety through gentler instrumentation, and minimize the risk of iatrogenic pulp exposure—critical advantages in behaviourally challenging or medically complex children. Future research should prioritize cost-effectiveness analyses, standardize smart bur protocols for stepwise vs selective removal, and explore hybrid approaches (e.g., smart burs + bioactive liners) to enhance remineralisation. Smart burs represent a promising, evidence-based tool for clinicians committed to tissue preservation and child-centred care.

3 | IMPORTANCE OF PRESERVING TOOTH STRUCTURE IN PRIMARY TEETH

Primary teeth are important for eating, speaking, and esthetics, as well as for guiding the eruption and maintaining the space for the permanent teeth. The best space maintainers (SM) for permanent dentition are the natural primary teeth. The best space maintainers (SM) for permanent dentition are the natural primary teeth. If primary tooth loss is unavoidable, it may lead to loss of space and results in crowding, impaction, and super-eruption of the opposing teeth, which could lead to malocclusion and lifelong consequences in the permanent dentition.¹²

4 | CONVENTIONAL CARIES EXCAVATION AND ITS LIMITATIONS

Previously, a surgical approach using a conventional rotary carious tissue removal method was used for tooth and cavity preparation focused on preparing appropriate space to place particular restorative materials. When managing carious primary teeth, the surgical method is less preferred as it removes extensive tooth structure where the tooth morphology already presents the challenges of thin enamel and dentine and relatively large pulp chambers. Furthermore, the majority of the techniques using surgical approach require the use of local anaesthesia, rubber dam and produces noise, and consequently discomfort, and fear among children in particular (Frencken et al. 2012). Traditionally, complete caries removal procedures such as stepwise technique have been used to remove deep caries in a non-selective way. Stepwise technique consists of the elimination of both firm and soft dentin in deep caries removal. This procedure may cause pulp exposure and excessive removal of tooth structure, and it is performed in two different visits by placing a temporary restoration between appointments. This conventional method presents some disadvantages; for instance, a high risk of irreversible pulp damage, which results in higher costs to the patient, or an increase in office visits¹³

5 | INFECTED VS AFFECTED DENTINE

During the 19th century, G.V. Black suggested that carious tissue should be removed until sound physiological dentin was reached, although this procedure may lead to pulp exposure. Almost a century later, Fusayama improved caries removal techniques by recognizing two different types of dentine: inner demineralized zone or affected dentin and outer contaminated or infected dentine. The inner zone presents a firm consistency, as there is a little resistance while removing it. As this zone is susceptible to remineralization, it should be respected and maintained. The outer zone presents soft dentin as it is highly contaminated, and should be completely removed during our restorative procedures¹³.

6 | SMART BURS- DESIGN, COMPOSITION AND MECHANISM OF ACTION

The polymer bur, a disposable self-limiting instrument, was first introduced by Boston in 2003. Its design principle is based on the difference in hardness between various dental tissues. Manufactured from medical-grade polyether ketone-ketone, the bur possesses a Knoop hardness value of 50 and features straight, shovel-shaped cutting edges. Its mechanism of action involves a plowing motion, whereby the blades initially compress the carious dentin locally and then displace the softened material along the surface of the underlying sound dentin. The process continues until the blades fracture at the surface level, dislodging the loosened debris, which is then brought to the surface. When

in contact with healthy dentin, the bur's cutting capacity is markedly reduced, resulting in abrasion rather than cutting of sound or minimally affected tissue. Due to this property, polymer burs are considered "dentin-safe" and "self-limiting." This technique provides a conservative, patient-friendly option for the removal of dentinal caries and can help encourage positive patient behaviour during restorative procedures in pediatric dentistry.¹⁴ Smart burs II are a relatively recent and novel introduction for selective dentin caries removal. Unlike the conventional burs, they are "self-limiting" as their cutting edges are shovel-like straight and not spiral. Smart bur II is preferred over first-generation (SMARTPREP) because the plastic used was not durable when run at rotary speeds above 1000 rpm. The introduction of Smart bur II provides significant changes in design and materials used in the fabrication of the bur allowing its use at 4000 rpm without damage to the bur's integrity.¹⁵

7 | CLINICAL TECHNIQUE

The surrounding gingiva of the selected tooth was first anesthetized by topical anaesthesia (Lidocaine Topical aerosol USP 15% w/w). Rubber dam (Coltene Rubber Dam Kit Hygienic) isolation was done for better visibility and to improve the efficiency of the operator. To expose the carious dentin, unsupported enamel was first removed from each tooth using a high-speed handpiece under water cooling. The carious dentin was then removed with smart bur (group 1), ceramic bur (group 2), and diamond point (API) (group 3) heat generation under water irrigation to prevent and prevent pulp damage using a slow-speed contra-angle handpiece (API) with light, discrete strokes that were directed from the centre of the lesion outward. Cutting was performed until no flakes of softened dentin stopped coming out and the bur discontinued to progress into the healthy dentin. Caries excavation was verified with the visual and tactile method and was further verified by caries detector dye (MAARC Find Fast Caries indicator) as suggested by the manufacturer. The caries detector dye was dropped onto an applicator tip and then placed into the cavity. After 10 seconds, the dye was rinsed off with water, and scoring was done by a coinvestigator without knowledge of assignment. The restoration was done with glass ionomer cement¹⁵

8 | LIMITATIONS OF SMART BURS

Goyal A et al found that, polymer burs although selective in carious dentin removal has the disadvantage of incomplete caries removal that led to the repeated change of burs and lesser patient acceptance due to vibration and more time consumption. The reason for longer duration of time taken by smart bur can be attributed to the fact that polymer bur gets abraded quickly and loses its cutting efficiency when contact sound dentin and new bur is attached to the handpiece for complete caries excavation. Such abrasion does not occur with ceramic bur. Therefore, repeated change of bur was required until complete caries removal was

achieved.¹⁵ Krishnaveni et al showed that polymer burs required significantly more time for caries excavation than both tungsten carbide and ceramic burs. Caries removal efficacy was highest with tungsten carbide burs, followed by ceramic burs, while polymer burs showed the lowest efficacy, following were the findings of this study- The caries removal efficacy of both the conventional tungsten carbide bur and ceramic bur is superior when compared with the polymer smart bur. Ceramic burs are more efficient than polymer burs in minimally invasive caries excavation. Polymer smart burs have the limitations of incomplete caries removal as well as increased time consumption in caries excavation. Polymer smart bur and ceramic bur were patient-friendly, causing minimal discomfort during caries excavation¹⁴ A randomized clinical study by Vishwanathiah S et al showed that pain perception among children was lower and overall satisfaction was higher in the smart bur group, whereas caries removal efficiency was higher in the conventional carbide bur group. Therefore, we conclude that restoration using smart burs minimizes pain and enhances cooperation of pediatric patients.¹⁶ Smart Bur II was more conservative in the carious dentin's removal than carbide bur. Smart Bur II was as efficient as carbide bur in caries removal.¹⁷

9 | CONCLUSION

Smart burs represent an addition to minimally invasive pediatric caries management because their self-limiting design preferentially removes soft, infected dentin while helping preserve affected dentin and sound tooth structure. This biological selectivity is particularly relevant in primary teeth, where thin hard tissues and relatively large pulp chambers make excessive excavation hazardous. By supporting pulpal protection, conserving space maintainers, and reducing the aggressiveness of treatment, smart burs align closely with contemporary child-centred restorative principles. Available clinical evidence also indicates potential advantages in comfort, pain reduction, and cooperation, which may be meaningful for anxious or behaviourally challenging patients. Nevertheless, smart burs should not be regarded as a universal replacement for conventional instruments. Their slower cutting action, wear on contact with sound dentin, need for repeated bur changes, and variable caries removal efficiency can lengthen treatment and demand careful technique and case selection. Clinical success therefore depends on using appropriate clinical assessment, isolation, and a restorative strategy suited to lesion depth and patient needs. Further studies should compare long-term pulp outcomes, restoration survival, cost-effectiveness, and standardized protocols. Overall, smart burs are best viewed as a conservative adjunct that can enhance tissue preservation and patient experience when used judiciously within evidence-based pediatric dental care.

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