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REVIEW

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Does dental rehabilitation under general anaesthetic contribute to the development of temporomandibular disorders in children and adolescents? A scoping review

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Abstract

Background: Temporomandibular disorders (TMDs) have multiple aetiological factors. Although some evidence suggests invasive and lengthy dental procedures may contribute towards TMD development, there is a relative paucity in the literature regarding an association between elements of paediatric dental general anaesthesia (pDGA) and TMDs. This review aims to consider the impact of dental rehabilitation (and its constituent elements) performed under general anaesthesia on the development of TMDs in childhood and adolescence and identify theories and/or gaps in knowledge which may benefit from future research.

Methods: Due to the need to preliminarily examine the nature and extent of the current evidence base, a scoping review approach was chosen. The review was conducted based on the framework provided by the methodological working group of the Joanna Briggs Institute (JBI) for conducting systematic scoping reviews. Electronic databases MEDLINE, Embase, Scopus, Web of Science and Cochrane Library were searched as well as the grey literature using OpenGrey, Nexis, Ethos, Google Scholar and ProQuest, with eligible studies uploaded onto Zotero (Mac Version 5.0.96.2).

Results: A total of 810 records were identified. After removing duplicates and those not available in English, 260 were identified for title and abstract screening. Seventy-six records underwent full-text review of which only one met the broad inclusion criteria. The most common reasons for exclusion were no specific relation to general anaesthesia, not specifically relating to dental treatment and only being concerned with TMD management. The included study found that while development of TMDs following dental rehabilitation under GA did occur in children, whether the problems caused by treatment were exacerbated by other elements of the pDGA process remains unknown.

Conclusion: This review has confirmed a distinct paucity of research in this field. While there is no current tangible scientific evidence that common and routine dental procedures lead to TMD, the literature shows that alterations to any one or a combination of critical factors can contribute to TMD development, which may be

collectively exacerbated by iatrogenic macrotrauma during the pDGA process. We have highlighted elements of pre-, peri- and post-operative pDGA, alongside biopsychosocial factors, which may contribute to TMD development in childhood and adolescence and may benefit from future research.

KEYWORDS
biopsychosocial, comprehensive care, exodontia, general anaesthesia, paediatric dentistry, temporomandibular disorder

1 | BACKGROUND

Temporomandibular disorders (TMDs) are defined as 'a collection of conditions affecting the temporomandibular joint (TMJ), masticatory muscles and/or associated structures'.[1] While patients typically present between 20 and 40 years old, TMDs are also known to occasionally occur in children and young people (CYP), with the reported prevalence varying widely in the literature (4.2%–34%).[2,3] This wide variation, itself, may be due to differences such as the populations studied, diagnostic criteria and research methods utilised, or even the inter- and/or intra-rater variations of examining practitioners.[2,4–6] Anecdotal reports suggest TMD prevalence in CYP may be increasing in the United Kingdom (UK), and a recent study carried out across paediatric dental clinics at UK dental hospitals reported a period prevalence of 0.57%.[7]

Temporomandibular disorders have a multifactorial aetiology. There is insufficient evidence to suggest a correlation between any single predisposing factor and a patient's presenting signs (findings identified during examination) and symptoms (findings described by patient/parent).[2] Previously suggested aetiological factors include microtrauma, macrotrauma, anatomical factors, orthodontic treatment, psychosocial factors, systemic and pathological factors, and genetic and hormonal factors.[8] Macrotrauma, for example, may even be iatrogenic in nature, instigated during invasive dental treatment such as third molar extraction and lengthy dental procedures such as root canal therapy, where the mouth is kept open for a prolonged period of time, resulting in overextension of the mandible and elongation of the lateral, sphenomandibular and stylomandibular ligaments.[9–11]

Management of dental caries is the primary reason for general anaesthesia (GA) in CYP in the United Kingdom; in 2019/20, there were 55 137 finished consultant episodes for children and adolescents having teeth extracted under GA.[12,13] Paediatric dental treatment carried out under general anaesthesia, where mouth opening is prolonged over the period of the procedure (without breaks), may present a conceivable form of 'macrotrauma',[13] on top of the suggestion by some authors that the variable force applied to the mandible during different procedures can traumatise one or both TMJs. Sahebi et al.[9] recommend breaking long appointments into short intervals allowing the TMJ to rest and prevent iatrogenic TMJ injury, something which is not routinely practiced during treatment under general anaesthesia. Not only does treatment under GA carry a risk of mortality, but endotracheal intubation has also long been considered another form of macrotrauma and a risk factor for development of TMDs due to the forces applied with the laryngoscope during which TMJ structures are stretched.[13,14]

Research into jaw pain in children and young people is an emerging area of interest, with the British Society of Paediatric Dentistry (BSPD) and Faculty of Dental Surgery of the Royal College of Surgeons (England) awarding a recent Pump-Priming Grant for novel research into understanding the experience and needs of young people who have TMDs.[15] As there is currently no research relating to the adolescent experience of TMD and with such a multifactorial aetiology, it is more important than ever to explore possible additional aetiologies of TMD in this cohort of patients.[16] A recent study by Shih et al.,[17] which assessed occlusal changes and development of TMJ issues following dental rehabilitation under general anaesthetic in children, found that nearly a quarter of participants reported TMJ dysfunction during the follow-up period. Data also suggest the prevalence of TMD signs and symptoms increases with age[2]; hence, with a rise in the amount of TMD reported in adolescents, alongside increasing numbers of dental general anaesthetics, it would be prudent to ascertain whether patients have previously undergone dental rehabilitation under general anaesthesia (henceforth referred to as paediatric dental general anaesthesia [pDGA]).

The authors hypothesised there would be a relative paucity in the literature regarding a relationship between pDGA and its constituent elements contributing to TMD development; hence, due to the need to preliminarily examine the nature and extent of the current evidence base, a scoping review approach was chosen.[18] This review aims to consider the impact of dental rehabilitation (and its constituent elements) carried out under general anaesthesia on the development of TMDs in childhood and adolescence and identify theories and/or gaps in knowledge which may benefit from future research.

1.1 | Review question

The research question was as follows: 'Does dental treatment performed under general anaesthesia contribute to the development of temporomandibular disorders in children and adolescents?' The United Nations Convention on the Rights of the Child defines 'child' as 'every human being younger than age 18 years', and 'adolescence'

as 'beginning at age 10 years and continuing through age 19 years'.[19] For the purpose of this research, 'children and adolescents' were defined as those aged 18 years and under.

2 | METHODS

The review was conducted based on the framework provided by the methodological working group of the Joanna Briggs Institute (JBI) for conducting systematic scoping reviews.[20] Although scoping reviews are rarely conducted solely with the view of identifying and analysing gaps present in a given knowledge base, as they tend to be a useful approach for rapid review of evidence in emerging fields and/or topics, identification and analysis of knowledge gaps is a common and valuable indication for conducting a scoping review.[21] A significant advantage of scoping reviews is that they allow for an iterative process when establishing inclusion and exclusion criteria—this, in turn, allows authors to keep the search as broad as possible until relevant themes emerge and can be further explored.[22]

2.1 | Search strategy

The relevant published and grey literature were identified via literature searches developed in collaboration with a librarian. Electronic databases were searched (MEDLINE, Embase, Scopus, Web of Science, Cochrane Library) on the 9 July 2022, alongside a generalised search-engine (Google) generated web-based search. The Ovid MEDLINE database was searched using the search strategy outlined in Box 1. This search strategy was amended appropriately for each database—including search terms, combined MeSH terms and key concepts based on the review question. In addition, references of included articles were screened for further findings of interest.

Efforts were made to identify any relevant unpublished 'grey' literature through searches of appropriate websites and databases such as the now-defunct OpenGrey as well as Nexis and Ethos, Google Scholar and ProQuest using the same keyword searches used in the Scopus database search.[22]

2.2 | Eligibility criteria

There was no restriction to study design or date of publication. Relevant articles were selected according to the following inclusion criteria:

- Principally focused on the child and adolescent population (<18 years old).
- Any study focused on both dental care provision under general anaesthesia and temporomandibular disorders.
- Article available in English.
- All grey literature accepted, as defined by GreyNet International.[23]
- Searches covered the period from the establishment of each database system until the instigation of the search.

Exclusion criteria included no access past the title and abstract, and where no translation was available into the English language.

2.3 | Study selection and data extraction

Full article review was performed following assessment of the article title and abstract, where possible. Eligible studies were uploaded into Zotero (Mac Version 5.0.96.2). Duplicate articles identified through the electronic searches were removed manually. The remaining list of full articles and titles with abstracts were reviewed by the authors during video conferencing meetings via Zoom (Mac Version: 5.0.4). Articles were subsequently marked as either 'potentially relevant' or 'not relevant', according to our pre-defined inclusion criteria. All potentially relevant articles were read in full and further reviewed as being relevant or not relevant. A data extraction spreadsheet allowed for data analysis using a framework approach.[21] A calibration exercise was carried out by both reviewers before the commencement of data extraction. No disagreements were noted. The headings of the data extraction spreadsheet are shown in Box 2.

2.4 | Data synthesis

A thematic approach was used to assess the identified literature with a qualitative synthesis planned to explore any findings from the included studies due to the expected heterogeneity between studies.[24]

3 | RESULTS

A total of 287 records were identified in the initial database searches of MEDLINE, Embase, Scopus, Web of Science and Cochrane Library. Records were excluded from the review if they were as follows[1]: in a language other than English[2]; hard copies of full-text articles not being available; or[3] articles not relevant to the established and defined categories. Records lacking relevance to the defined categories were grouped by not being specifically related to general anaesthesia, not specific to dental treatment, only being concerned with TMD management, and no mention of a link between dental treatment under GA and TMD. Following removal of duplicates and those not available in English, 121 records were screened by title, abstract and keywords for relevance, with 80 removed. These were subsequently categorised according to their relevance to the research question. Forty-one records were sought for retrieval, with four unavailable in hard copy version past the title and abstract, despite further attempts to contact the corresponding author. There were 37 articles which underwent full-text evaluation of which only one met the eligibility criteria in full.[17] This study's characteristics are listed in Table 1.

BOX 1 OVID MEDLINE search strategy.

1. exp Child/
2. exp Adolescent/
3. exp Young Adult/
4. exp Pediatric Dentistry/
5. exp Dental Care for Children/
6. (child* or adolescen* or young people or young patient*).ti,kw
7. 1 or 2 or 3 or 4 or 5 or 6
8. exp Temporomandibular Joint Disorders/
9. (Temporomandibular Disorder* or Temporomandibular Joint Disorder* or Temporomandibular Joint Dysfunction* or Temporomandibular Joint Syndrome or TMD or TMJD).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
10. exp Temporomandibular Joint/
11. 8 or 9 or 10
12. exp Anesthesia, General/
13. (general anesthe* or general anaesthe*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
14. 12 or 13
15. (dental or dentist*).mp. or exp Dentistry/ or exp Dental Care/ [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
16. 14 and 15
17. exp Anesthesia, Dental/
18. 13 and 17
19. 16 or 18
20. 7 and 11 and 19
21. exp Tooth Extraction/
22. exodontia.ti,kw
23. comprehensive dental care.mp. or exp Comprehensive Dental Care/
24. 21 or 22 or 23
25. 7 and 11 and 24
26. 25 and (anesthe* or anaesthe*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
27. 20 or 26
28. 11 and 19
29. limit 28 to 'all child (0 to 18 years)'
30. 27 or 29
31. limit 30 to English language

Identification of further records ($n=523$) was carried out via searching the grey literature as well as Google Search, Google Scholar and ProQuest. Following removal of duplicates and those not available in English, 139 records were screened with a further 94 removed following review of title and abstract. Forty-five records were sought for retrieval with six unable to be retrieved. Thirty-nine were assessed for eligibility and excluded based on their lack of relevance to the aforementioned descriptors. No additional records identified via other methods met the eligibility criteria.

While some records did reference a possible causation between TMD and intubation for GA, the majority were excluded due to no specific mention of a link between aspects of dental treatment under general anaesthesia being a possible aetiology of TMD. A summary of source selection is presented as a flowchart (Figure 1), based on the PRISMA 2020 guidelines.[25]

4 | QUALITATIVE SYNTHESIS

The only study to meet the full inclusion criteria comprised a prospective clinical study carried out in China between September 2020 and March 2021.[17] The study aimed to quantify the changes in occlusion following placement of preformed metal crowns (PMCs) using T-Scan III (a computerised system that can provide dynamic occlusal data on occlusal contact area, total of force [TOF], asymmetric ratio of occlusal force and occlusion time [OT]), and to investigate whether TMJ dysfunction occurred after PMC placement. The occlusal vertical dimension (OVD) was measured using a dental vertical dimension gauge; TMJ dysfunction signs were recorded by the clinical dysfunction index (Di); and TMJ dysfunction symptoms were recorded using a questionnaire. The data were collected before treatment (T0), 1 week after treatment (T1), and 1 month (T2) and 3 months (T3) after treatment.

Forty-seven participants signed informed consent forms, four did not meet the inclusion criteria and three left the study. Forty participants were followed up for 3 months.

All treatments were performed under general anaesthesia and consisted of 'conventional' tooth preparation, that is occlusal, mesial and distal surface reduction. No PMCs were placed using the Hall Technique, where no surface reduction is carried out. All procedures were performed by five experienced clinicians blinded to the study. There was no control group in this study, which the authors listed among various limitations to their study. The study did not investigate the potential cumulative

BOX 2 Data extraction fields.

1. Author(s)
2. Year of publication
3. Title of publication
4. Aims/purpose
5. Source of publication
6. Country of author(s)
7. Type of study design
8. Study population and sample size (if applicable)
9. Intervention type and control (if applicable)
10. How outcomes are measured
11. Key findings that relate to the review question

TABLE 1 Characteristics of included study.

Criteria	Data extraction
Author(s)	Shih et al.
Publication year	2022
Publication title	Assessment of occlusion and temporomandibular joint after placing preformed metal crowns on all primary molars in children
Aims/Purpose	To quantify the changes in occlusion following the placement of preformed metal crowns (PMCs) using T-Scan III, and to investigate whether TMJ dysfunction occurred after PMCs.
Publication source	Database Search: International Journal of Paediatric Dentistry
Country of author(s)	China
Type of study design	Prospective Clinical Study
Study population/Sample size	40 participants followed up for 3 months. Mean age: 4.25 ± 0.63 years Age range: 3–5 years Boys accounted for 52.5% (21 of 40), and girls accounted for 47.5% (19 of 40).
Intervention type and control	Placement of PMCs under general anaesthesia. Conventional PMC preparation—occlusal, mesial and distal surface reduction; NB. Not Hall Technique. No control group.
Outcome measures	The participants underwent occlusal examinations with a computed occlusal analysis system. The vertical dimension of occlusion (VDO) was measured using a dental vertical dimension gauge; TMJ dysfunction signs were recorded by the clinical dysfunction index (Di); and TMJ dysfunction symptoms were recorded using a questionnaire. The data were collected before treatment (T0), 1 week after treatment (T1), and 1 month (T2) and 3 months (T3) after treatment during follow-up visits. Repeated-measures analysis of variance and Friedman's test were used for occlusal data analysis. In addition, the Di and symptoms were compared over time using McNemar's test.
Key findings relevant to review question	The occlusal contact area 3 months after treatment did not return to the pre-treatment status ($p = .03$). The total of occlusal force at the 3-month follow-up visit increased significantly ($p = .009$) compared with that at the pre-treatment status. Six patients exhibited mild dysfunction of TMJ during the follow-up period, and nine patients confirmed the symptoms of TMJ dysfunction in the questionnaire.

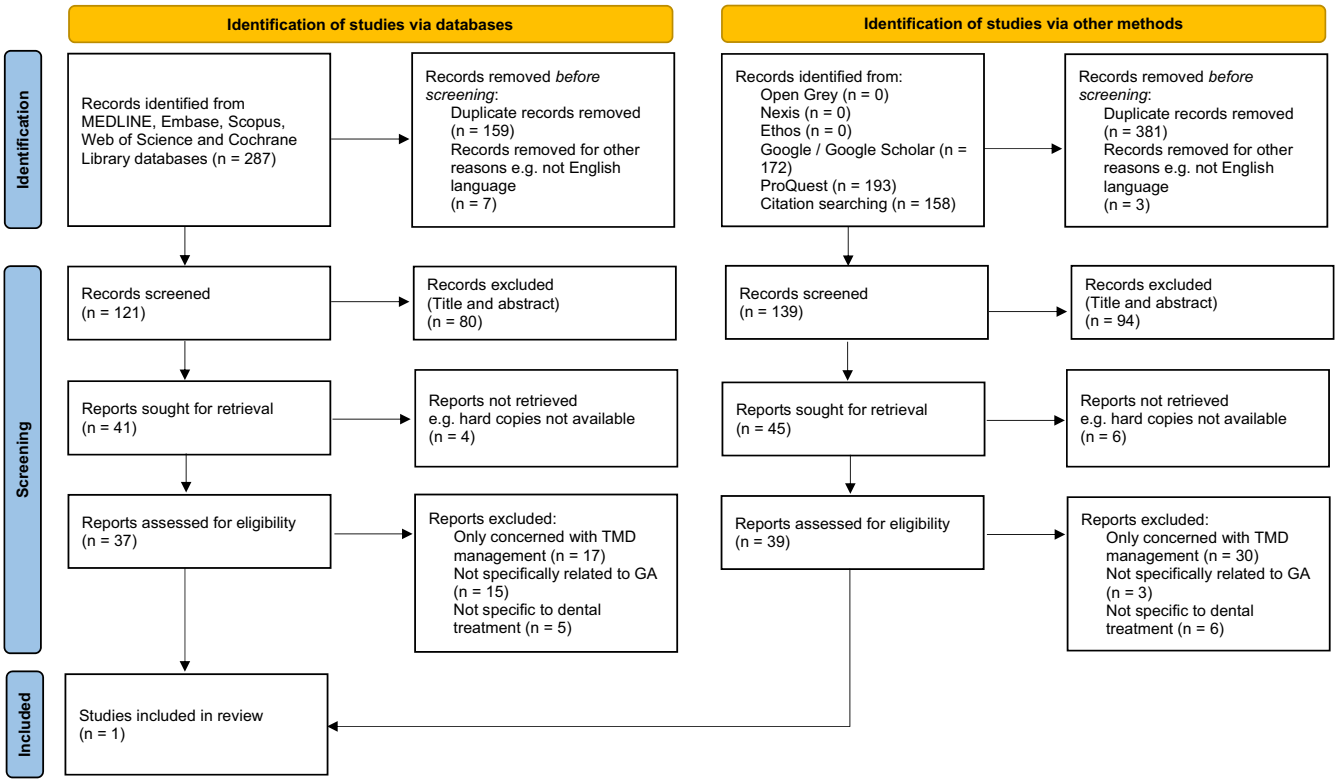

FIGURE 1 PRISMA 2020 flow diagram.

effect of pDGA factors (i.e. macrotrauma from intubation, treatment force and length of opening) and if they had an effect on TMD development.

The occlusal contact area 3 months after treatment did not return to the pre-treatment level ($p = .03$). The total of force at three-month follow-up increased significantly ($p = .009$) compared with that at the pre-treatment assessment. The asymmetric ratio of occlusal force at one-month follow-up visit was restored to pre-treatment levels. Concerning the occlusion time, no significant changes were observed for any time intervals ($p = .069$). The OVD was recovered at the one-month follow-up visit. While the statistical analysis of TMJ dysfunction showed no significant differences in the Di and TMJ dysfunction symptoms before and after treatment ($p > .05$), six patients exhibited mild dysfunction of TMJ during the follow-up period, and nine patients confirmed the symptoms of TMJ dysfunction in the questionnaire. The authors conclude that whether occlusal interferences caused by the PMC restoration of primary molars will increase TMD prevalence in childhood or beyond remains unknown, necessitating further research.

5 | DISCUSSION

To the best of our knowledge, this is the first scoping review to attempt to evaluate the impact of dental treatment carried out under general anaesthesia in the development of temporomandibular disorders in children and young people. This review followed the robust methodology and guidance for the conduct of scoping reviews developed by the JBI.[20] An extensive search strategy was employed with broad inclusion criteria as it was expected there would be a relative paucity of studies available in the literature. Despite the broad approach taken, only one study was included in the qualitative synthesis. Further to the information presented in the qualitative synthesis, a narrative review of key themes identified from the literature during full-text review, comprising elements of pre-, peri- and post-operative dental treatment performed under general anaesthesia, have been reported, which may contribute to development of TMDs, alongside implications for future research and clinical practice.

The Commissioning Standard for Dental Specialties, provided by the Office of the Chief Dental Officer (OCDO), describes pDGA as an 'essential adjunct to providing care where the surgical intervention is complex or to those children who are cognitively immature, highly anxious or who have a medical condition' where general anaesthesia is the most appropriate or only way to deliver dental treatment.[26]

While incidence of pDGA for caries management remains the primary reason for utilisation of GA in the United Kingdom,[13] it is also important to consider the frequency of pDGA from an international perspective. The literature shows that many other countries such as Australia, New Zealand, Canada and the United States also utilise pDGA.[27–30] One study[31] goes as far to describe the number of UK pDGAs 'puzzling', given that in mainland Europe many countries

simply do not offer GA for dental procedures or do not utilise pDGA to a similar degree.[28,31]

5.1 | Pre-operative considerations

Paediatric treatment approaches under general anaesthesia typically fall into two categories: exodontia (extraction-only) and comprehensive care (restorative treatment ± extractions). Generally, the type of airway and anaesthesia chosen will, therefore, depend on the age of the patient and the proposed dental treatment.

5.1.1 | Nasal masks and laryngeal mask airway (LMA)

Nasal masks and LMA are typically used for exodontia-only treatment lists, where the operator will place a gauze pack intra-orally to prevent too much mouth breathing and decrease the risk of aspiration.[32] Anaesthetists are often happier to use flexible LMA for all but the most complex extractions as they also provide an excellent barrier to aspiration.[33] The LMA requires firm holding by the anaesthetist during exodontia as it tends to move and any downward pressure during extractions may obstruct it—inadequate support of the patient's head will not prevent excessive movement of the neck, while inadequate jaw support and insufficient counter-pressure to extraction forces may well lead to increased stress and strain on the TMJ.[31,32]

5.1.2 | Endotracheal intubation

Comprehensive care treatment tends to take longer than exodontia-only procedures and often involves copious intra-oral irrigation.[32] The literature advises comprehensive care is better performed with an endotracheal tube and throat pack in place to prevent aspiration, which can occur even with a cuffed endotracheal tube.[31] LMA are not normally utilised for comprehensive care as they leave little space for conservative procedures to be performed.

Endotracheal intubation, specifically orotracheal intubation, has long been considered a risk factor for the exacerbation and even development of TMD.[14,34] Battistella et al.[35] state that during intubation, the rotational and translational manoeuvres used by anaesthetists to achieve maximum mouth opening, as well as the atraumatic passage of an endotracheal tube, 'may result in damage to the TMJ apparatus due to the excessive forces being applied either manually or with the laryngoscope'.

Routine assessment of TMJ function by the anaesthetist is advised both pre- and post-operatively to avoid or minimise temporomandibular complications—which may not be possible in children and adolescents with complex neurodisabilities.[14,36,37] One paper noted that TMJ damage may occur due to extended lengths of time that structures are in 'stressed' positions, such as during difficult orotracheal intubations.[38] Jaw thrust and direct laryngoscopy manoeuvres are routinely done on anaesthetised patients, where the TMJ has lost some of the protection afforded by the tone of surrounding muscles.[39] In addition, Gadotti et al.[40] feel that this loss of muscle tone due to the unconsciousness and muscular relaxation can predispose to greater joint mobilisation and therefore pose a risk of developing future TMD symptoms.

5.2 | Peri-operative considerations

5.2.1 | Mouth Props

Devices such as the McKesson Mouth Prop (Figure 2) come in a variety of sizes (small, medium, large) and are routinely used in pDGA to facilitate intra-oral visualisation, as well as protection of the teeth and soft tissues. Mouth props are 'wedged' between the mandibular and maxillary teeth, opposite to the side being treated, and prevent involuntary closure for the duration of the procedure. When the mouth is held open, the supra-hyoid, digastric and lateral pterygoid muscles, among others, are active—prolonged contraction of the lateral pterygoid can pull the articular disc forwards and it is proposed that when a patient is biting on a prop, these muscles relax and the muscles associated with mouth closing become active producing less tension on the discal attachments.[41] Although its trapezoid shape is designed to fit easily into the mouth, use of the largest size available facilitates greatest visualisation, however, an unconscious patient is unable to communicate discomfort from TMJ nociceptors when a prop is too large, which may lead to inadvertent over-stretching, stress and injury of the TMJ and increase the risk of developing a future TMD.

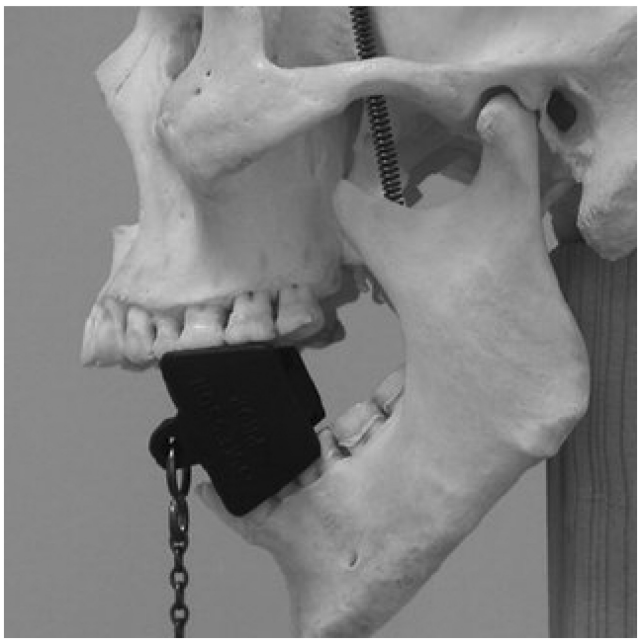

FIGURE 2 McKesson Mouth Prop.

5.2.2 | Exodontia

The majority of centres offering pDGA provide extraction-only services; requiring less time, less equipment and are therefore less-expensive than comprehensive care.[13] Although extraction forces have never been directly measured, clinical experience suggests wide variance in both force required for tooth extraction and time required for the procedure.[42] It is worth stating, however, that while technical difficulty and anticipated extraction force are not synonymous, most clinicians would agree that they are somewhat related.[42] Children undergoing pDGA usually require multiple extractions, including balancing and compensating extractions of primary and permanent teeth.[13] The unconscious patient is unable to provide the antagonistic resistance offered when they are awake, which may result in excessive, unresisted, downward forces during extraction of multiple mandibular teeth.[1] In addition, modern instruments such as cowhorn or eagle-beak forceps have been argued by some to actually increase pressure on the TMJ and thus increase the risk of developing future TMD, a direct contradiction to their intended benefit.[43]

5.2.3 | Comprehensive care

The Royal College of Surgeons encourages a holistic approach to pDGA treatment so that a child is considered 'dentally' fit by the end of the procedure, reducing the need for any future GA treatment.[44] Comprehensive care pDGAs therefore last substantially longer than exodontia-only lists, usually anywhere between 1–3 h in duration. Simply keeping your mouth open for a few minutes, let alone an extended period of time, can cause considerable TMJ discomfort. As such, this type of 'iatrogenic macrotrauma' where the mouth is propped open for an unnatural, sustained period, outside of the rest position (and considerably longer than treatment carried out awake in the dental chair) placing strain on the TMJ, may be a factor in the development of TMDs in CYP.[2,45] The OPPERA study into clinical orofacial characteristics associated with risk of first-onset TMD found that such prolonged mouth opening may predict onset of future TMD.[38,46] The exodontia component of comprehensive care plans is also typically performed toward the end of procedure, placing further pressure on a TMJ that has already been under significant stress and strain.

5.3 | Post-operative considerations

5.3.1 | Anaesthetics

Temporomandibular joint dislocation can occur at any point during direct laryngoscopy, intubation or extubation, or even anytime in the post-operative period—this can lead to internal derangement of the joint and may therefore be a precursor to development of a future TMD.[47] Dental treatment, especially that performed under GA, has also long been considered a risk of TMJ dislocation, further emphasising the importance of an anaesthetic assessment post-operatively by the anaesthetist.[48] In addition, grinding or clenching teeth during wakening and recovery was also reported to place stress on the TMJ.[36]

5.3.2 | Occlusion

The relationship between TMD and occlusion remains controversial with some authors believing that occlusion is a primary factor in the onset of symptomatic TMD, whereas others feel that occlusion plays no role in this at all.[49] Occlusion in paediatric patients in the mixed dentition is in a continuous state of flux with the sequential exfoliation of primary teeth and eruption of permanent successors. A paediatric patient's occlusion and occlusal vertical dimension (OVD) may change significantly following dental treatment under general anaesthesia, through, for example placement of preformed metal crowns (PMCs) using the Hall Technique.[50] Sahebi et al.[9] contend that a sudden change in occlusal status can be a precursor to TMD through the notion that occlusal interferences may lead to parafunctional habits such as bruxism[50]; however, the bruxism construct has shifted from a pathology or disorder to a motor activity, that may even have potential protective relevance; hence, in this context, there is enough evidence since 2018, in which many investigations demonstrate that occlusal interferences do not lead to bruxism (clenching and grinding).[51,52] In addition, the literature advises that such temporary increases in OVD settle for the majority of, if not all, patients within 4 weeks,[53] further negated by the superior adaptability of the masticatory system to occlusal interferences in growing children.[9]

Some studies recommend regular closure of the mouth under pDGA to check the occlusion; however, when nasotracheal intubation has been performed[54–56] the autonomic nervous system and muscles normally responsible for closure are impaired; therefore, closure of a patient's mouth under GA does not provide accurate information about their true occlusion.[50,56] In addition, despite Kampe et al.[57] proposing that unstable tactile responses on PMCs or restorations may induce abnormal patterns of mandibular movements which exceed the masticatory system's tolerance level,[9] a systematic review by Manfredini et al.[58] found there is no ground to hypothesise a major role for dental occlusion in the pathophysiology of TMD. They found that any association between mediotrusive interferences and TMD did not imply a causal relationship and may even have the opposite implication, that is interferences being the result and not the cause of TMD, with psychosocial and genetic issues as well as muscle-related overload, more consistent in the literature in the pathophysiology of temporomandibular disorders.[58]

5.4 | Psychological and social factors

Temporomandibular disorder is a complex musculoskeletal disorder with a multifactorial aetiology. Physical, behavioural and emotional

factors overlap and interact in TMD; therefore, an approach based upon a biopsychosocial model is recommended in its diagnosis.[38] In children there appears to be no gender predilection for TMD, however, with increasing age into adolescence, the sex ratio increases to approximately 2:1 (female:male).[38] A patient's psychological profile can influence their susceptibility to TMD—some patients are more susceptible than others, where one patient may develop TMD symptoms from relatively simple dental treatment under GA that may not necessarily lead to symptoms in others.[41] The interrelationship between symptomatic TMD and psychological factors, such as anxiety, has been observed in several studies on children and adolescents.[59–61]

Dental anxiety is one of the primary indications for use of pDGA in children and adolescents, as opposed to other pharmacological behaviour management methods.[62] Children who undergo pDGA are not only high-risk for poorer oral health as they age, pDGA status is also associated with greatly increased odds of dental anxiety in adolescence.[63] One study described adolescents who reported low self-perceived oral health having significantly more TMD pain.[64]

While low socioeconomic status (SES) has also previously been reported as a potential risk factor for TMD in adults, studies in children have reported little to no purported association.[60,65,66] Schwendicke et al.[67] found that lower SES is significantly associated with an increased caries risk. In addition, children from lower SES report higher rates of dental anxiety, which correlates with increased utilisation of pDGA for caries management of children and adolescents of lower SES, which may be a precursor for TMD development in adolescence.[68]

6 | CLINICAL IMPLICATIONS/AREAS FOR RESEARCH

Despite lacking high quality in vivo evidence, the hypothetical risk of TMD from dental rehabilitation performed under pDGA, alongside the known morbidity and mortality of GA (and repeat GA) usage, should lead a desire to avoid pDGA wherever possible[69]; however, research shows there are patients for whom pDGA will be the only viable option, such as those who lack cooperative potential, when the proposed treatment is too extensive or when other conscious sedation options have not been successful.[70]

Conscious sedation methods allow a patient to provide verbal feedback, for example when the force associated with dental extractions is too great on the TMJ or when their jaw hurts from being open for too long and they need a break as suggested by Sahebi et al.[9] and also permit sufficient assessment for occlusal interferences following PMC and/or restoration placement. While Manfredini et al.[58] found a lack of clinically relevant association between TMD and dental occlusion in the literature, their findings did highlight a higher prevalence of mediotrusive (non-working side) interferences in TMD patients; hence, further research into novel techniques for checking the occlusion under GA such as those described by Dimashkieh and Pani[71] and Gallagher et al.[72] could look at methods of reducing any mediotrusive interferences introduced during pDGA rehabilitation. Future studies should also take into account the potential cumulative effect of pDGA factors (i.e. macrotrauma from intubation, treatment force and length of opening) and if they have an effect on TMD development.

The American Academy of Pediatric Dentistry[2] state that controversy surrounds the significance of signs and symptoms in children and adolescents and the value of certain diagnostic procedures; hence, a recent Delphi study was performed to develop a standardised protocol for TMD diagnosis in children and adolescents by adapting the pre-existing DC/TMD Axis I used in adults.[73] The DC/TMD is the most widely used diagnostic criteria for TMD and as this adapted DC/TMD, alongside the psychosocial status and pain-related disability within DC/TMD Axis II, will provide a more comprehensive standardised process for the collection of clinical information in children and adolescents,[64,73] there may be scope for a question in the history questionnaire instrument of Axis I, to determine how many of those children and adolescents presenting with TMD have experience of pDGA.

Consideration must also be given to those specialties, outside the realms of dentistry and anaesthesiology, who also utilise the mouth under general anaesthesia such as otorhinolaryngology (ear, nose and throat [ENT]) where a study by Maini et al.[74] found a link between TMD and tonsillectomy following the use of a Boyle–Davis mouth gag during the procedure. Furthermore, a study by Kundi et al.[75] concluded that the duration of mouth gag usage during tonsillectomy should be reduced to cause less post-operative TMJ pain and trismus.

7 | STRENGTHS AND LIMITATIONS

Despite only one study meeting the inclusion criteria for qualitative synthesis, a major strength of this scoping review is the extensive and comprehensive literature search employed across relevant databases and grey literature.[24] As a relative paucity of studies was anticipated, a further strength of this review is the inclusion of a broad range of study types, rather than limiting inclusion criteria to, for example systematic reviews, meta-analyses and randomised control trials.[20,21]

It is important to note that although this review focused on elements of dental rehabilitation during pDGA that could represent a risk factor for temporomandibular disorders, many of the studies described were in adult populations; thus, some caution should be exercised with regard the generalisability to children and adolescents. As this body of literature had not yet been comprehensively reviewed, however, our robust methodology allowed reconnaissance to clarify the conceptual boundaries around pDGA and TMD development and to identify research gaps and recommendations for future research.

One major limitation of this review is the omission of articles not available in the English language. While inclusion of studies in non-English languages is likely to reduce the risk of systematic bias and

increase generalisability, Sumner et al.[24] advise that their inclusion is also likely to increase resource challenges, namely cost, time and expertise in the primary language of the study. To this end, it is worthy of note that Morrison et al.[76] found no evidence of systematic bias when limitations to English language were placed on search criteria in systematic review-based meta-analyses in conventional medicine.

Both reviewers (CD and BW) involved in record identification, screening, selection and data extraction were not blinded to author names nor study origin, as such this may have introduced an element of selection bias. Each reviewer did, however, work independently and this approach aligns with the approach recommended by the Cochrane Collaboration for Systematic Reviews of Interventions, where at least two reviewers should undertake these tasks, and that blinding is not essential, as it does not 'provide a benefit nor protect against bias'.[24,77]

8 | CONCLUSIONS

As anticipated, this review has highlighted a distinct paucity of research in this field with only one study meeting our inclusion criteria. Our reconnaissance has, however, revealed elements of pre-, peri- and post-operative dental rehabilitation under general anaesthetic, alongside biopsychosocial factors, which may contribute to TMD development in childhood, adolescence or beyond. While there is no current tangible scientific evidence that common and routine dental or medical procedures lead to TMD, the literature shows that alterations to any one or a combination of critical factors, including psychological factors, can contribute to TMD development, which may be collectively exacerbated by iatrogenic macrotrauma during the pDGA process. We have identified theories and/or gaps in knowledge which will undoubtedly benefit from future research. More studies of higher evidence quality need to be conducted on TMJ disorders in relation to dental procedures, including those carried out under general anaesthetic.

AUTHOR CONTRIBUTIONS

CD developed the protocol; extracted the data; reviewed and quality appraised the papers; analysed the findings; drafted, developed and critically revised the manuscript. BW reviewed and quality appraised the papers; analysed the findings; drafted, developed and critically revised the manuscript. The manuscript has been approved by both authors.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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