HALL VERSUS CONVENTIONAL PREFORMED METAL CROWNS: RADIOGRAPHIC IDENTIFICATION BY PEDIATRIC DENTISTS

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ABSTRACT

Hall Versus Conventional Preformed Metal Crowns: Radiographic Identification by Pediatric Dentists

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Background: It is assumed that *Conventional* preformed metal crowns (PMCs) are usually well adapted to the primary molars, while it has been claimed that the *Hall technique* (HT) PMC is an oversized, poorly fitting crown with overhanging margins. PMCs, if present in children, are usually identifiable on routine bitewings.

Aim: To investigate if pediatric dentists (PDs) were able to identify or perceive any radiographic differences between HT PMCs versus conventional PMCs and to assess the perception and acceptability of HT by PDs over time.

Method: An online cross-sectional questionnaire of 25 questions survey was sent via global dentistry society groups, to PDs across the globe between 1st January to the 31st March 2020. It included 10 randomly selected bitewings showing PMCs (five HT and five conventional). A score out of 10 was calculated for the PMCs detection. T-test, Pearson's and Fischer's Chi-square, and Odd Ratios (OR) were calculated ($p<0.05$).

Results: Responses of dentists (N=476) from 58 countries were obtained, with 97% reporting that they used PMCs in their practice. The majority (98.7%) had heard/understood HT, while 79% used it. There was a clear shift, towards supporting the use of the HT, over time with an opinion change OR of 11.154 [95% confidence interval (CI): 6.006- 20.715]. More than two thirds (67%) of the PDs thought that there was no radiographic difference between HT and

conventional PMCs (out of the 10 bitewings provided), and only five PMCs were identified correctly [average correct score of 4.9 (±1.73) out of 10]. The remainder (33%) who thought there were differences, scored higher than those who had the opposite view (5.31±1.22, and 4.68±1.9 respectively, $p<0.00001$). No one managed to identify all the 10 PMCs correctly, however, the participants were able to successfully identify HT PMCs on bitewings 4.63 times more than conventional PMCs (OR for successfully identifying HT PMCs; 24.857 [CI: 15.059-41.028] compared to an OR for successfully identifying conventional PMCs; 5.361 [CI: 3.089-9.304], $p<0.0001$).

Conclusion: Most of the surveyed PDs identified the PMC type in only half of bitewing radiographs provided. Despite that they perceived that there was no clear radiographic difference between HT and conventional PMCs on bitewings radiographs, the chance of them recognizing HT PMCs on these bitewings was almost five times higher than conventional PMCs. There was a clear supportive shift in opinion over time, for the use of the HT.

DEDICATION

The side of success that you don't see is the constant push towards the next. On that note, I would like to dedicate this research to:

To Mom and Dad, it's impossible to thank you adequately for everything you've done, from loving me unconditionally to raising me in a stable household, where you instilled traditional values and taught me to celebrate and embrace life. I could not have asked for better parents or role-models. Am always grateful to you for your constant effort to encourage me to do the finest work.

There is nothing in this world that is quite as strong and enduring as a mother's love. My mama-Tejal Raja, has been a source of motivation and strength during moments of despair and discouragement. Her motherly care and support have been shown in incredible ways, from taking care of my health during the times when I would forget myself to encouraging me to do my best during difficult times, which were equally tough for her as well, are commendable.

The strongest person that I have known, my pappa - Mohanraja, who, despite going through a difficult phase in his life, made sure to put on a smile across my face, and took care of me by providing me with the time and space, when needed, to concentrate on my research in this journey. His hardworking nature to achieve the finest results, his lessons on "you can lead a horse to water, but you can't make him drink", and being grateful to what you have, has what molded me into a person that I am today.

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DECLARATION

I declare that all the content of this thesis is my own work. There is no conflict of interest with any other entity or organization

Name: Sahaana Mohanraja

Signature: 

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ABBREVIATIONS

(AAPD) - American Academy of Pediatric dentistry

(ArAPD) - Arabian Academy of Paediatric dentistry

(ART) - Atraumatic Restorative treatment

(BSPD) - British Society of Paediatric Dentistry

(CI) - Confidence Interval

(CoVid 19) - Corona Virus

(EAPD) - European Academy of Paediatric Dentistry

(ECC) - Early childhood caries

(F) - Fluoride

(GCP) - Good Clinical Practice

(GDP) - General Dental Practitioner

(GIC) - Glass Ionomer Cement

(HT) - Hall Technique

(IAPD) - International Association of Paediatric Dentistry

(MBRU) - Mohammed Bin Rashid University of Medicine and Health Sciences

(MBRU-IRB) - Mohammed Bin Rashid University-Institutional Review Board

(MID) - Minimally Invasive Dental procedure

(OR) - Odd's Ratio

(PD) - Pediatric Dentist

(PMC) - Preformed Metal Crowns

(SDF) - Silver Diamine Fluoride

(UAE) - United Arab Emirates

(UK) - United Kingdom

(US) - United States

(WHO) - World Health Organization

1. INTRODUCTION

Dental caries in children continues to be a significant health problem worldwide. According to the World Health Organization (WHO) it is a known fact that dental caries of the primary teeth is the most common chronic disease in children globally[1]. Asymptomatic and non- pulpal dental caries of the primary molar can be successfully treated restoratively by using plastic restorative materials[2]. However, in cases of multi-surface caries in primary molars, it is advised to use preformed metal crowns (PMCs) especially in high caries risk individuals[3]. PMCs can be fitted either after a surgical reduction/preparation of the molar or non- invasively by using the Hall technique (HT)[4]. The HT for sealing caries uses a PMC and glass ionomer cement. The technique involves cementing an appropriately sized glass ionomer cement-filled PMC on a primary molar with non pulpally involved dental caries, using no local analgesia, no removal of carious tooth structure, no cutting the crown margins to natural length, as opposed to the usual PMC procedure[5].

The first step after deciding the treatment for a tooth by the HT is to assess the tooth shape, contact points areas and occlusion. As there is some elasticity in the periodontal ligament that can absorb the displacement of crown, the HT crown can be seated successfully onto primary molars. This depends on the contact point shape and the child's willingness to bite the crown in place. Fittings of crown can sometimes be difficult as some teeth may have a broad contact point. Orthodontic separators can be useful when placed mesial and/or distal to the contacts when fitting a HT crown.

Three to five days after the first appointment, the patient returns for the removal of the orthodontic separators. Space is created mesially and distally that will negate the need for crown preparation. After crown selection, the crown should then be filled with a self- curing glass ionomer cement and positioned over and on the tooth. The operator then digitally presses the crown through the contact points so that the crown flexibly "clicks" on the tooth and fits snugly. The excess of the glass ionomer cement is wiped off. The crown should be leveled with the occlusal plane and blanching of the gingivae will be noticed buccally and lingually indicating an adequate seal[4].

While it is assumed that conventionally fitted PMCs are usually very well adapted to the primary molars, there have been questions raised regarding the fit of the HT crown in comparison. It has been claimed the HT PMC is considered an oversized, poorly fitting crown with overhanging margins[5]. This may logically raise concerns regarding the association with chronic gingival inflammation[6], and delay of the normal eruption of a permanent succedaneous tooth as it engages the overhanging margins of a PMC placed with the HT, and hence stopping some pediatric dentists from practicing the HT[7].

Radiographic examination of primary molar teeth is conducted using bitewing radiographs and is recommended according to the patient's caries risk to detect dental caries on the proximal surfaces[8]. When such bitewings are taken adequately, they show other areas such as the furcal regions. When primary molar teeth are restored with PMCs, they are usually followed up clinically and radiographically, with the latter being bitewing radiographs. While these radiographs are indicated for the above justified reasons, as a collateral finding they also show the PMCs, their margins, and their size relative to the teeth they restore.

While it is assumed that such difference in sizes of PMCs is noticeable clinically by specialists in pediatric dentistry, the difference in the radiographical identification of a HT PMC from a conventional PMC and the ability of pediatric dentists to differentiate between them has not

been formally studied, hence this study. The HT technique is known globally [6, 7, 9], however, as far as the authors know, only one unpublished study (conference poster)[10] had assessed the radiographic adaptation of PMCs using the HT, however the results remained unknown. No study has been conducted or published in the United Arab Emirates (UAE) nor globally, regarding this aspect. Therefore, this gap in the scientific literature prompted the authors to conduct this study.

2. REVIEW OF THE LITERATURE

2.1. Dental caries

Dental caries in children continues to be a significant health problem worldwide. According to the WHO it is a known fact that dental caries of the primary teeth is the most common chronic disease in children globally[1]. It exceeds the prevalence of all other known disease occurring in children, making it to be recognized as a physical impairment [11]. It affects the growth in the pre-school children and the quality of life, as the dietary intake being affected from the pain, and the abscesses caused from chronic pulpal inflammation affecting the growth through the metabolic pathway [12]. Dental caries is formed as a result of complex interaction between the fermentable carbohydrate and bacteria that produces acid along with other factors such as saliva and teeth [13]. Highly cariogenic diet and improper toothbrushing are important risk factors [14].

According to AAPD (American Academy of Pediatric Dentistry), Early Childhood Caries (ECC) is defined as "the presence of one or more decayed (non-cavitated or cavitated lesions), missing (due to caries), or filled tooth surfaces in any primary tooth in a child under the age of six" [15]. Although, the general etiology of ECC appears to be similar to other types of caries, there are several factors unique to young children such as oral hygiene in early childhood, immature host defense mechanism and behavioral patterns associated with feeding that causes ECC [16]. The risk factors of ECC includes consumption of sugars, pre chewed rice and nocturnal breastfeeding over the age of 12 months [17]. Feeding practices where the child is put to bed with the bottle containing formula, cow's milk or juice are associated with ECC [18]. ECC can progress rapidly to cavitation stage within a span of 6-12 months, forcing early intervention necessary [19]. Also, the pain and suffering associated with the caries affect the child's oral health quality of life [20]. ECC is initially noticed as a white spot lesion, but when the demineralization

progresses past the enamel tooth layer, caries progression is rapid, and intervention is required. Whether a lesion will progress, stay the same, or reverse is determined by the balance between protective factors and pathological factors[21] . The effects of pathological factors such as cariogenic bacteria, frequency of ingestion of fermentable carbohydrates and salivary dysfunction, are balanced by protective factors such as most salivary components, phosphates, fluoride, and extrinsic antibacterial substances (such as chlorhexidine), salivary fluoride, fluoride from extrinsic sources, and substances that stimulate salivary function. Prevention, intervention, and reversal of dental caries can be enhanced by either reducing the pathological factors or enhancing the protective factors [22]. Furthermore, it has been demonstrated that caries status in the primary teeth can be used as an indicator for predicting carious lesions in the permanent teeth [23]. Childhood dental caries requires the intervention of a pediatric dentist[24] in terms of operative and preventative management, whether conventional or minimal intervention approached are used.

2.2. Conventional Vs minimal interventive caries management

Dental caries is a process which is reversible at its earliest stage, and it can also be arrested at its advanced stage [25]. It is well known, that advanced dental caries is the source of dental pain [26]. Hence, different modalities of treatment have been introduced in the past, for children experiencing dental anxiety, to help them cope up with the dental treatment, and at the same time, changing their perception towards dental procedures. There are different treatment methods in treating a carious molar, ranging from sealants for pit and fissure with no carious removal to using the HT [27]. There has been recent drive, in the current climate of the Corona Virus (CoVid-19) pandemic to adopt more minimally invasive methods[28].

2.2.1. Minimal interventive caries management

This involves dental prevention, arresting caries mechanisms and minimally invasive restorations. Simple daily toothbrushing using fluoridated toothpaste (1000 ppm Fluoride (F)) has been found to arrest 45% of carious lesions on the proximal surfaces of anterior primary teeth in kindergarten children[29]. While professional application of 5% sodium fluoride varnish can remineralize early enamel caries, and 38% silver diamine fluoride (SDF) is effective in arresting dentinal caries[30]. Fluoride varnish weighs advantages in public health dentistry, owing to its safety and practicality in usage in young children's teeth[31], but recently SDF outperformed fluoride varnish in regards to arresting caries [32] and it was also found to be better or equivalent to glass ionomer cement (GIC) [33]. SDF is a cost-effective method of managing carious lesion. The mechanism being- silver acting as an antimicrobial, fluoride promoting remineralization, and the ammonia stabilizing high concentrations in the solution, SDF works towards arresting the carious lesion [34]. Fissure sealants are another effective caries prevention tool, which also aids in preventing the progression of the early non-cavitated carious lesion [35]. Resin based sealants are of particular interest in preventing carious lesion on the occlusal surface of the permanent molars, reducing the caries by between 11% and 15% [36]. Sealing pit and fissures without any removal of the carious lesion has been widely practiced to primarily prevent accumulation of food debris [27, 37]. Use of sealants have been found to be safe and effective, both in carious and non-carious occlusal surface in teeth which shows early evidence of caries activity [36].

Atraumatic restorative technique (ART), involves the removal of decalcified tooth tissue, with the use of hand instruments only, without any use of rotary instruments and restoring the cavity with an adhesive filling [38]. Standard excavators are used to manually excavate the caries, which helps in retention of the restorative material. GIC is used as the restorative material in this technique. The ART technique has been reported to show higher survival percentage over the

traditional amalgam restoration in cases of single surface restorations [39]. In rural and suburban areas, extraction is the common dental treatment. With ART, success rate has been found to be 79% for single surface restoration and 55% for more than single surface restoration, making it the most preferred mode of treatment among children who were pleased and showed little fear, and also making it the promising mode of caries treatment in rural and suburban area [40]. ART has been proven to be performing equally well as a conventional treatment using amalgam restoration would do, in occlusal surfaces after 6 years [41]. Another method of sealing a cavitated carious lesion without any intervention is by cementing a PMC using glass ionomer cement [42]. The latter is the main concept of the HT. A recent assessment of pediatric dental guidelines and caries management alternatives in the post COVID-19 period reviewed the above methods and advocated their use in contemporary clinical dentistry [28].

2.2.2. Conventional restorative treatment

Conventional treatment includes, traditional removal of the carious lesion, using a rotary instrument along with local anesthesia [24] . This treatment approach, involves removal of significant amount of dental structure [43] and the cavity is restored using a suitable material, such as composite or compomer in adjunct with sealant, or the use of amalgam in two surface class II restorations or PMCs [44]. Although dental amalgam has relatively high longevity [45], and is still in the latest AAPD guidelines[46], there has been a significant fall in the use of amalgam restoration by the dentists over the time [47] owing to its risk of neurotoxicity from the mercury that is present in dental amalgam[48]. Since then, the use of composite resin as a restorative material has been increased, which also satisfies patient's aesthetic needs [49]. This conventional treatment also termed as "one step complete caries removal" includes the removal of all the carious lesion, thereby, holding its own disadvantages, which includes weakening of the tooth structure, causing pulp exposure which calls out for further treatment [43]. While, when it comes

to restoration of a large carious lesion, multiple surface lesion, or an extensive decay in the primary molars, it is preferred to use PMCs as they provide protection from further decay and also provides increased longevity and durability [3]. It has been shown that the children treated with hand instruments alone experience less discomfort than the ones treated using rotary instrument [50]. In regard to children's dental anxiety, although the use of handpiece has been accepted, the use of injection instigates anxiety [51].

2.3. Preformed metal crowns

Preformed metal crowns (PMCs- also known as stainless steel crowns) are conventionally fitted following a traditional tooth preparation of the mesial, distal and occlusal surfaces [27] of the primary molar cemented with a luting agent [52]. PMCs have shown to have lower failure rate than a class II amalgam restorations[53] and is considered the most successful restorative modality for the multi-surface carious primary molar[2]. As mentioned previously, the indications for the placement of PMCs are restoration of a large carious lesion, multiple surface lesion, or an extensive decay in the primary molars [3]. Furthermore, they are also indicated for restoration of primary teeth with developmental defects such as molar incisor hypomineralization, enamel hypoplasia or hypomineralization, dentinogenesis imperfecta [54, 55], where an amalgam is likely to fail if the preparation of the proximal box extends beyond the anatomical line [56, 57], fractured posterior teeth [58], used as an abutment for space maintainer, in a tooth with a severe loss of tooth structure [59] and in patients treated under general anesthesia[60]. To avoid microleakage, and to attain good retention, and marginal adaptability, PMCs are placed 0.5-1mm subgingivally[61] . It is advisable to avoid any violations to the biological width while seating the crown subgingivally [62]. The use of infiltration anesthesia is always preferred to avoid any discomfort produced by the subgingival conventional tooth preparation[63]. Although, anesthesia usage is advocated to prevent any discomfort, the sight of needle remains

the most common trigger for dental anxiety in children [64]. As population's concern towards aesthetics increases, PMC may be becoming a less preferable option of restoration [65]. Further, they are contraindicated if the tooth preparation has resulted in insufficient tooth surface area, presence of deep bite, bruxism, periodontal disease, in partially erupted tooth, and in children allergic to nickel [66, 67]. Alternatively, zirconia crowns are used in aesthetically concerned patients [68] but these require extensive tooth preparation, which calls out for patient's cooperation [69].

2.4. The Hall technique (HT)

Traditionally, dental caries has been managed by complete removal of the demineralized dentine before placing the restoration, involving tooth preparation on the mesial, distal and occlusal surfaces that requires the use of local anesthesia [43]. The HT was recently prescribed in the management of carious primary molars, and it works by embalming the carious lesion from the oral environment using a PMC to seal the lesion, thereby, separating it from the nutrition that it would normally feed on receiving it from the oral environment. [70, 71] PMCs have shown to have low failure rates [53] but required specialist skills owing to the difficulty of placing them and the negative opinion that children and parents had towards PMCs [72]. Also, concerns regarding the adverse effects of the complete caries removal have been questioned [43]. The simplified HT method of using a PMC, was primarily reported and recognized in international literature during an audit in Scotland in the United Kingdom (UK) [73]. Dr Norna Hall [74], simplified her crown fitting technique and found that the PMCs fitted without any preparation or use of local anesthesia, gave similar outcomes to those fitted with the conventional method [75]. The first outcome was a retrospective analysis of Dr Hall's practice records addressing the HT [73]. The technique has since then, been assessed for its clinical success across the world [3]. However, with evidence supporting the "biological" approach over

"surgical" approach growing in line, the HT is one such "biological" approach, that involves sealing caries beneath the PMC without any removal of carious lesion thereby avoiding the need of local anesthesia [76]. There is a good evidence suggesting that if caries is sealed from the oral environment, its caries profile drastically decreases to low cariogenic community, thereby, halting the progression of the lesion [73, 77] and that the PMC may provide the best marginal seal. The HT, which utilizes all these principles is representative of the "biological" technique which has been borne out of clear understanding of the caries progression [78]. Contrary to the conventional model of PMC, neither the use of local anesthesia nor tooth preparation is required in HT[4]. The "no-drill" "no injection" technique has made HT more acceptable and favorable by both children and the parent [49, 79]. PMCs placed using HT, also shown to have increased longevity and favorable outcomes [80].

2.4.1. Indications and contraindications of the HT

The success of this technique depends on the careful selection of the cases. HT PMCs are indicated in primary molar teeth without any clinical signs or symptoms of pulpal pathology[81]. They include cavitated or non-cavitated lesion, occlusal lesion, and proximal lesion, where patient does not accept the conventional method that includes removal of the carious lesion with a handpiece with the use of local anesthesia [82]. A clear band of dentin must be visible between the carious lesion and the pulp [42]. Contraindications of HT include any signs or symptoms of irreversible pulpitis, radiographic or clinical signs of pulpal involvement or periapical pathology, near exfoliation, and tooth that are unrestorable even by conventional technique [53, 83]. The following is a summary of the HT indications and contraindications (Innes et al 2009 [84])

Indications

- Class I lesion, non cavitated, patient not able to accept fissure sealant, or conventional restoration
- Class I lesion, cavitated, patient not able to accept partial caries removal, or conventional restoration
- Class II lesions, cavitated or non-cavitated.

Contraindications

- Teeth with signs or symptoms of irreversible pulpitis or dental sepsis.
- Teeth with clinical or radiographic signs of pulp exposure or periapical pathology.
- Teeth that are unrestorable with conventional technique

2.4.2. Placement of HT PMCs

The HT usually requires two appointments. The tooth receiving the crown is initially assessed for tight contact points. In the presence of tight contacts, orthodontic separators are placed through the mesial and distal contacts of the tooth with the help of floss being threaded through the separators. The patient is then seen 3 to 5 days later, when, on removal of separators, one would notice the approximal spaces, that would facilitate the fitting of the PMC. The elasticity of the periodontal ligament offers a successful placement of the HT crowns as the periodontal ligament can absorb the displacement of the crown [4, 70]. After choosing the appropriate size of the crown, it is filled with luting cement, preferably GIC and is placed and seated over the tooth. With the help of the patient, by asking him to bite over the cotton roll, the PMC is seated in a way it ensures good seal by engaging in the approximal contact points [73, 75].

2.4.3. Preference and acceptance of the HT

Despite the availability of global evidence to validate the HT, there has been mixed responses to its use [7]. The HT is crafted around the straightforward biological principle that if caries is sealed from the oral environment, its caries profile drastically decreases to a low cariogenic community, thereby, halting the progression of the lesion or at least slowing down the caries progression, thus protecting the tooth from any pulpal sepsis until it exfoliates [73, 77, 85] and the PMC provides the best marginal seal. In addition, the HT aims to increase the child's compliance by eliminating the need of local anesthesia. Not just does it seals the carious lesion, but it also makes the dental experience less traumatic, by which it helps in reducing the child's dental anxiety[86]. Pediatric dentists should take into consideration regarding the patient's age, pain perception, treatment option. These factors are important while considering a treatment option. There is high degree of acceptance being noticed among parent and children with PMCs placed using HT [79]. Although, aesthetic related concerns with PMCs placed using HT were raised by the parents and children, parents agreed once the advantages of the PMCs were explained [87].

2.5. Perception of the HT [75]

Although, HT has been found to show three times higher survival rate than ART in the most recent study and various other studies[88-90], there have been questions raised over the years.

Concerns regarding the caries progression have been questioned as there is no caries excavation and the seal of the PMC has been questioned [5, 91] but studies had proven that creating the biological seal reduces the viability of bacteria existing in the lesion, thereby, arresting the caries [92]. The chances to precipitate post-operative infection has been raised in regards to HT as the progression of the carious lesion will also be difficult radiographically once sealed with PMC [93]. Which is possible, if an improper case selection is done[4], with reports of a far less

number of failure of the HT when compared to its success [94]. Premature contact with the newly fitted PMC has been a major concern addressed by the dental practitioners [70]. The changes caused in the occlusion following the placement of PMC using HT, have been shown to resolve in 4 weeks period [95, 96]. The adaptability and the overhanging margins of a PMC placed using HT had also been questioned in regards to potential associated chronic gingival inflammation and the eruption of the successor tooth [97-99]. Also, because of presumed larger PMC to tooth ratios marginal leakage in HT PMCS where much higher than conventional ones, *in vitro* conditions [100]. Therefore, it is presumed that these PMCS are much larger than tooth they are adapted to, to the extent that they are noticeable clinically and even radiographically.

2.6. Radiographic examination

Dental radiographs are a diagnostic tool for proper diagnosis and treatment planning [101]. The decision to make radiographs should be based on clinical judgement, when a dentist expects the presence of a disease or when there is a scope for an undetected lesion to be left untreated, which would adversely affect the patient's dental health [102]. Radiographs aid in detection of caries, pathological conditions, any developmental disturbances in the tooth, dental injuries, severity of periodontal disease, overhanging restoration [103, 104]. They also aid in differentiating the type of developmental disturbance, as in the case of amelogenesis imperfecta, with variation in the contrast corresponding to its type [105]. Presence of secondary caries is not detected clinically unless it has a restoration defect or margin discrepancies. Hence the combined criterion of both clinical and radiographical assessment will help in diagnosing secondary caries [106]. Diagnosing a primarily, non cavitated lesion accurately is important as the disease progression can be halted and the tooth structure be preserved with minimal intervention [107, 108]. Also, enamel-dentinal caries located interproximal often goes unnoticed by just clinical examination [109].

Among the various carious lesions, proximal caries, which progress at a rapid rate, are the most challenging to detect [110] and as such, radiographic techniques have been established to be superior to clinical examination in the detection of this type of lesion[111, 112]. The recommended radiographic technique for caries detection is the *bitewing* projection [113]. Specifically, bitewing radiographs have been found to be superior in detecting interproximal carious lesions than the conventional panoramic radiograph[114, 115 116]. The posterior bitewing radiograph should capture the crowns of the teeth, from the distal surface of the canine to the distal surface of the most posterior erupted molar, without any overlap [117].

The benefits of bitewing radiographs have been quoted to include- detection of caries that otherwise would have been missed, to monitor a lesion, and to estimate the extent of the lesion. The interval between the bitewing radiography is to be tailored to each patient depending on their caries risk assessment [103]. Often, the prevalence of occlusal and proximal carious lesions are underestimated with just the clinical examination, while when the same population is assessed using both clinical and radiographical examination tool, they has been noted to have a significant increase in decayed missing filled surfaces score, thus, confirming the value of bitewing radiographs [118].

With the developing technology, digital radiography has overtaken the conventional dental radiography. Along with their added advantage of ease of manipulation, enhancement, storage and exchange for referrals, they also carry the environmental advantage by dose reduction and decrease use of resource [117], elimination of dark room, concerns regarding processing errors, and chemical solutions [119]. Although, both conventional and digital radiographs hold similar diagnostic accuracy, with some studies also stating the conventional method to be superior in

terms of accuracy [120], it should be noted that the digital radiographic technique requires less ionizing radiation, making it more preferable for routine dental practice [121, 122].

Bitewings radiographs could also be used to assess the status of the tooth restored using PMCs[7], to evaluate their marginal extension and adaptation of crown margins and eventually evaluate the interproximal bone level in addition to the furcal area and potential secondary caries [123]. In a related matter, the marginal contours of strip crowns, which may look good under clinical examination, may be shown to be defective restorations accurately by radiographic evaluation [124]. Radiographs are also helpful in the assessment of the prognosis of a tooth following restoration, to evaluate the efficacy of the restoration materials [88, 125].

PMCs placed using HT could be assessed radiographically during the routine diagnostic radiographic examination, taking into consideration regarding the concerns associated to the adaptation of the PMC with HT, and their alleged overhanging margin. To the author's knowledge, there has been no published studies covering the radiographic appearance and aspect of the HT. A poster presentation at the AAPD conference 2018 in Honolulu[10] evaluated whether bitewings radiographic appearance of PMCs on posterior primary teeth differed between those seated with the HT compared to those seated using the traditional technique in the opinion of pediatric dentists of varying experience levels. However, the results were never mentioned despite the poster appearing online. Hence the need for this study arose, which was designed to radiographically assess PMCs, placed using the HT and with the conventional technique, by pediatric dentists.

2.7. Null hypothesis

There is no difference in the radiographic appearance of the PMCs whether placed using the HT or the conventional technique as reported by pediatric dentists.

3. AIM

3.1. Aim of the study

To evaluate if pediatric dentists can identify radiographically whether PMCs on primary molar teeth were placed using the HT or the conventional technique.

3.2. Specific objectives of the study

1. To investigate if pediatric dentists thought there were radiographical differences between PMCs placed using the HT versus the conventional technique.
2. To assess if pediatric dentists were able to correctly identify HT or conventional PMCs in 10 given bitewings.
3. To study the perception and acceptability of the HT by pediatric dentists at the time they heard about it and at the time of the survey.

4. MATERIALS AND METHODS

4.1 Study design

A cross- sectional survey-based study.

4.2 Population

A sample of practicing pediatric dentists around the world. The sample was obtained between 1st January 2020 and 31st March 2020.

4.3 Sample size calculation

To assess a sample of global pediatric dentists, estimated to be around 68,000 [7], power sample calculation was conducted using a sample size calculator, confidence level (95%) and margin of error (5%) rendered the sample size required at 383 pediatric dentists needed (plus 20% non-response rate)[126-129] rendering the sample required for this study to be 460 pediatric dentists.

4.4 Study design (see survey sample-APPENDIX 1)

The research was proceeded in the form of an online questionnaire in the English language sent to pediatric dentists, through pediatric dentistry society representatives. This was conducted through published posts in the online Facebook Pediatric Dentistry Forum (that has a membership of 45000 pediatric dentists globally). Many of the members of this group are also members of other societies like the BSPD (British Society of Paediatric Dentistry), IAPD (International Association of Paediatric Dentistry), AAPD (American Academy of Pediatric Dentistry), EAPD (European Academy of Paediatric Dentistry), ArAPD (Arabian Academy of Paediatric Dentistry). We estimated that the survey was distributed to a total of 4790 members,

estimated by the number of total "views" of the posts. The post provided a link to the survey in *Microsoft Forms*®, which contained demographics including:

- Year of graduation
- Years of experience
- Gender
- Country

The survey included *Binary* (Yes/No) and *Likert* scale questions. The questionnaire also contained ten randomly selected radiographs (see below for randomization method) showing PMCs (see Appendix 1), five radiographs showing HT PMCs, and five radiographs showing conventional PMCs, but the images were randomly mixed in the survey. These radiographs were:

- Bitewings taken at Dubai Dental Hospital of patients who had been followed up after receiving treatment by the conventional or Hall technique PMC.
- Sourced from various pediatric dentists in the hospital.
- Anonymized showing no patient details.
- Showing tooth/teeth treated by the HT or,
- Showing tooth/teeth treated by conventional PMCs
- Grade 1 (or) Grade 2 (with no overlapping) quality bitewings[130]
- Excluding pulpectomy / pulpotomy treated teeth and Grade 3 quality bitewings.
- Selected from 40 bitewings chosen by consensus between two consultants in pediatric dentistry showing conventional and/or HT PMCs (until a total of 20 of each type was obtained).
- Ten radiographs were randomly selected (every fourth radiograph) to be used in the survey, thus ending with five radiographs for each type of PMCs
- These images were placed in no particular order in the survey. Randomized by a toss of a coin.

4.5 Score of correct answer

From the 10 bitewings used showing 10 PMCs (from PMC1 to PMC10) (see Figure 1), each radiograph was given one score. Thus, the total score was 10. When the correct type of PMC was identified, 1 point was scored. When the wrong PMC type was identified a score of zero was given (also a zero was given when the participant chose "don't know"). As both indicate that the assessor does not know the type of PMC on the radiographs (by answering wrong or by not answering at all). Thereafter a score of correct answers was calculated out of 10. [See Appendix 1 (green tick) for correct answer]. The participants were intentionally not informed of how many PMCs were of either the two types to reduce bias.

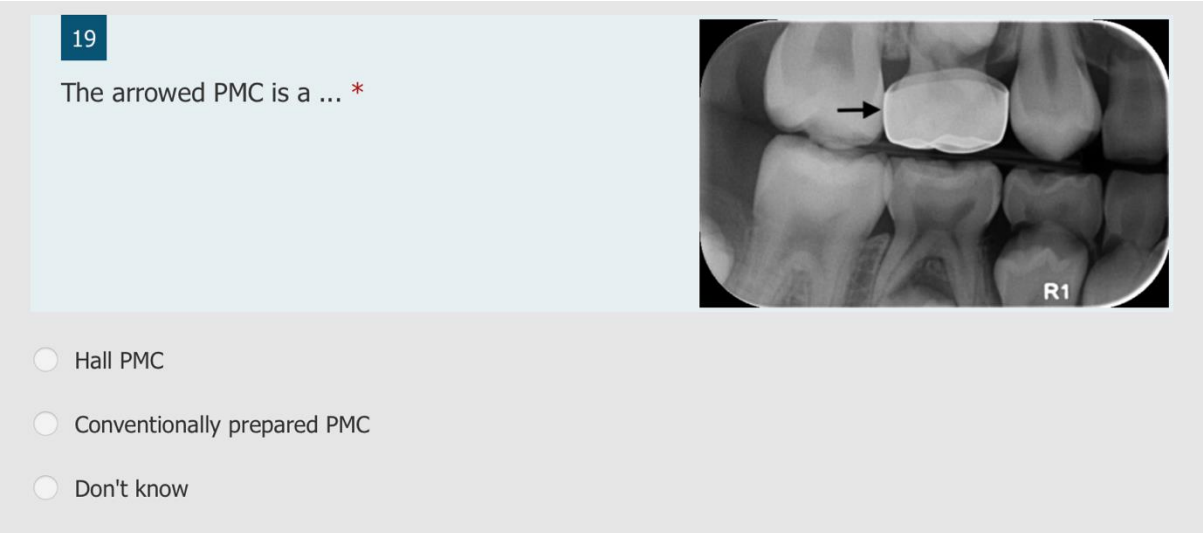

Figure 1: Q19 as an example showing a bitewing with an arrowed PMC

4.6 Validation of the questionnaire

The survey was piloted amongst 10 pediatric dentists to assess expert validity, usability, readability, and ease of completion. These responses were excluded from the final survey. Minor adjustments were made according to the feedback. The questionnaire was tested for internal validity and internal consistency using Cronbach's Alpha (C-α).

4.7 Outcomes and outcome measures

This study had two outcomes; 1) The ability of pediatric dentists to radiographically identify PMCs treated by the HT and PMCs treated conventionally. The outcome measures were scores based on the ten radiographs presented in the questionnaire and direct questioning. A secondary outcome was to assess and compare pediatric dentist perception of the HT prior to and at the time of the survey to assess if there was a change/shift in opinion about the HT when first heard about it and at the time of the survey. Demographic variables were used to identify any contributing factors.

4.8 Statistical analysis

Data was entered in the computer using IBM-SPSS for Windows version 25.0 (SPSS Inc., Chicago, IL). Categorical variables were described by using proportions and continuous variables were described by measures of tendency and measures of dispersion. The score of the correct answer of bitewing radiograph of different PMCs was calculated by summing the answers which was dichotomized to 0 and 1. Kolmogorov-Smirnov was used to test the normality of the score of the correct answer. The Mann-Whitney test was used to compare the means between the two groups. When comparing the means between more than two groups the Kruskal-Wallis test was used. The rate of change of opinion of the HT was measured from when first heard about it till the time of the survey. Exact Fischer Chi-square test was used to determine change from non-supportive to supportive use of the HT, and vice versa. A p-value of less than 0.05 will be considered significant in all statistical analysis.

4.9 Eligibility Criteria

4.9.1 Inclusion criteria

- Pediatric dentists who were willing to participate in the study.

- Pediatric dentists who were aware of and use PMCs in children.

4.9.2 Exclusion criteria

- Specialties other than pediatric dentists
- Dental therapists, dental hygienists, dental assistants and students
- Pediatric dentists who were unaware of PMCs.

4.10 Ethical considerations

This study was conducted in full conformance with principles of the "Declaration of Helsinki", Good Clinical Practice (GCP), and within the laws and regulations of the UAE/Dubai Healthcare City The ethical approval was obtained from the Research Ethics Review Committee at MBRU-Internal Review Board (IRB MBRU-IRB-2019-025 (See Appendix 2).

5. RESULTS

5.1. Validity and reliability of the questionnaire

The internal reliability of the questionnaire was tested. This yielded a Cronbach-α value of 0.812 indicating its validity, as test values range from 0 to 1.0, and values should generally be at least 0.6 to 0.7 or higher to indicate internal consistency and validity.

5.2. Demographical characteristics of the participants

5.2.1. Descriptive demographical statistics

Demographic data is shown in Table 1. A total of 476 pediatric dentists were included in the study, thus the sample size exceeded the power sample calculated. All of the participants completed all parts of the survey, so none were discarded. As highlighted above, we estimated that the survey was distributed to a total of 4790 members. Thus, the response rate was assumed to be around 9.9%. The proportion of females that participated in the study was higher than males with a total of 365 (76.7%) and 111 (23.3%) respectively. About 239 (50.2%) of the participants were in the age group of 31-40. The geographic data of the participants included their country of practice, country of completing undergraduate studies and country of completing specialization/post graduate studies. They were grouped under five regions, used for research health statistics and information systems and defined by WHO [131] as follows- America, Europe, Asia, Africa and Eastern Mediterranean regions. This classification has also been used in contemporary dental research[132].

Item	No (%) *
Age	
23-30	109 (22.9)
31-40	239 (50.2)
41-50	90 (18.9)
51-60	32 (6.7)
>60	6 (1.3%)
Gender	
Male	111 (23.3)
Female	365 (76.7)
Region* of practice	
America	100 (21)
Europe	74 (15.5)
Asia	80 (16.8)
Africa	12 (2.5)
Mediterranean	210 (44.1)
Region* of undergraduate studies	
America	92 (19.3)
Europe	76 (16)
Asia	97 (20.4)
Africa	11 (2.3)
Mediterranean	200 (42)
Region* of specialization	
America	111 (23.3)
Europe	103 (21.6)
Asia	86 (18.1)
Africa	10 (2.1)
Mediterranean	166 (34.9)

Table 1: Demographic statistics of the study. * WHO region

5.2.2. PMC and HT opinion and practice characteristics of the participants: Descriptive statistics

These are described in Table 2. Out of 476 participants, 471 (98.9%) were currently practicing pediatric dentistry with the majority (n=393, 82.3%) being specialists compared to 83 (17.7%) consultants. With regards to their clinical experience, the majority (n=310, 65.1%) had less than 10 years of experience. A very large majority (n=395, 82.9%) always/very frequently used PMCs in their practice.

Currently practicing full time	N (%)
No	5 (1.1)
Yes	471 (98.9)
Designation	
Specialist	393 (82.3)
Consultant	83 (17.7)
My experience	
< 10	310 (65.1)
10-20	118 (24.8)
21-30	39 (8.2)
31-40	2 (0.4)
>40	7 (0)
Use of PMCs in children	
Never	12 (2.5)
Rarely	18 (3.8)
Occasionally	51 (10.7)
Very frequently	218 (45.7)
Always	177 (37.2)
Number of patients treated using PMC in a week	
None	26 (5.5)
1-5	166 (34.9)
6-10	151 (31.7)
11-20	78 (16.4)
21-30	33 (6.9)
>30	22 (4.6)
Heard and understand HT	
No	6 (1.3)
Yes	470 (98.7)
Opinion when first heard about HT	
Totally opposed	22 (4.6)
Somewhat opposed	85 (17.9)
Neutral	121 (25.4)
Somewhat supportive	141 (29.6)
Totally supportive	107 (22.5)
Opinion now about HT	
Totally opposed	6 (1.3)
Somewhat opposed	31 (6.5)
Neutral	63 (13.2)
Somewhat supportive	139 (29.2)
Totally supportive	237 (49.8)
Using / have used the HT	
Never	102 (21.4)
Rarely	93 (19.5)
Occasionally	127 (26.7)
Very frequently	114 (23.9)
Always	40 (8.4)

Table 2: Characteristics related to pediatric dentistry status, experience, and HT PMC practice

The majority, 98.7% (470), were aware of the HT, while 78.6% (374) used the HT at the time of this survey. When asked about their opinion about the HT (when they heard about it for the first time), only 148 (52.1%) were supportive of it. When asked about their opinion about the HT (now; i.e at the time of the survey), an increase was noted as 376 (79%) were supportive. (see Figure 2).

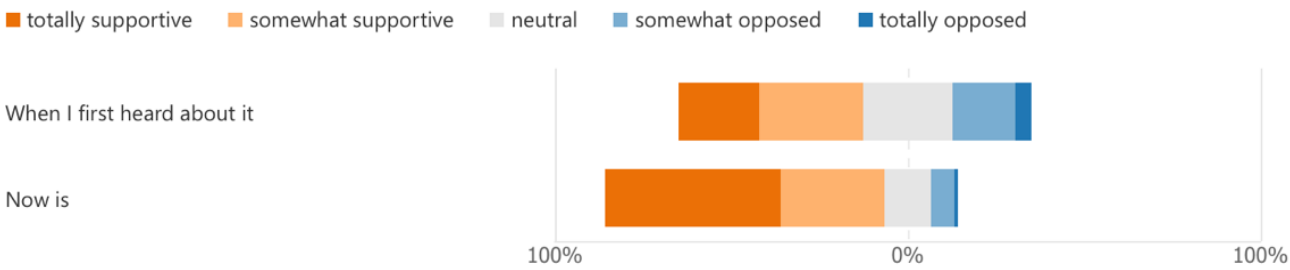

Figure 2: The perception of HT when first heard about it and at the time of the survey. Notice the shift to the left (more supportive).

Further sub-analysis was carried out to assess the shift in the opinion, from non-supportive to supportive, from the time participants heard about the HT to the time of the survey was conducted. The increase in the proportion of the HT supporters was very significant (Fisher's exact test, $p<0.0001$) with the clear shift in opinion change in every category of Likert scale (Figure 3). As described in Table 3, 29.6% who were initially non-supportive about the HT have changed their opinion to supportive at the time of the survey "now". While only 2.7% who were supportive of the HT "then" had become non-supportive "now". The likelihood that the change in opinion would occur from non-supportive to supportive was found to be high with an Odds Ratio of 11.154 [95% confidence interval (CI): 6.006- 20.715] (Table 4).

			"Now"		
			Non supportive	Supportive	Total
"Then"	Not Supportive	Count	87	141	228
		% of Total	18.3%	**29.6%**	47.9%
	Supportive	Count	13	235	248
		% of Total	2.7%	49.4%	52.1%
Total		Count	100	376	476
		% of Total	21.0%	79.0%	100.0%

Table 3: Crosstabulation of the shift in opinion at the time of survey "Now" compared to when they initially heard about the HT "Then".

		95% Confidence Interval	
	Value	Lower	Upper
Odds Ratio for Now (not supportive / supportive)	**11.154**	6.006	20.715
For cohort "Then" = not supportive	2.320	1.995	2.698
For cohort "Then" = supportive	.208	.125	.347
N of Valid Cases	476		

Table 4: Risk estimate (Odd's ratio) of change in opinion when first heard about the HT "then" and at the time of the survey "now".

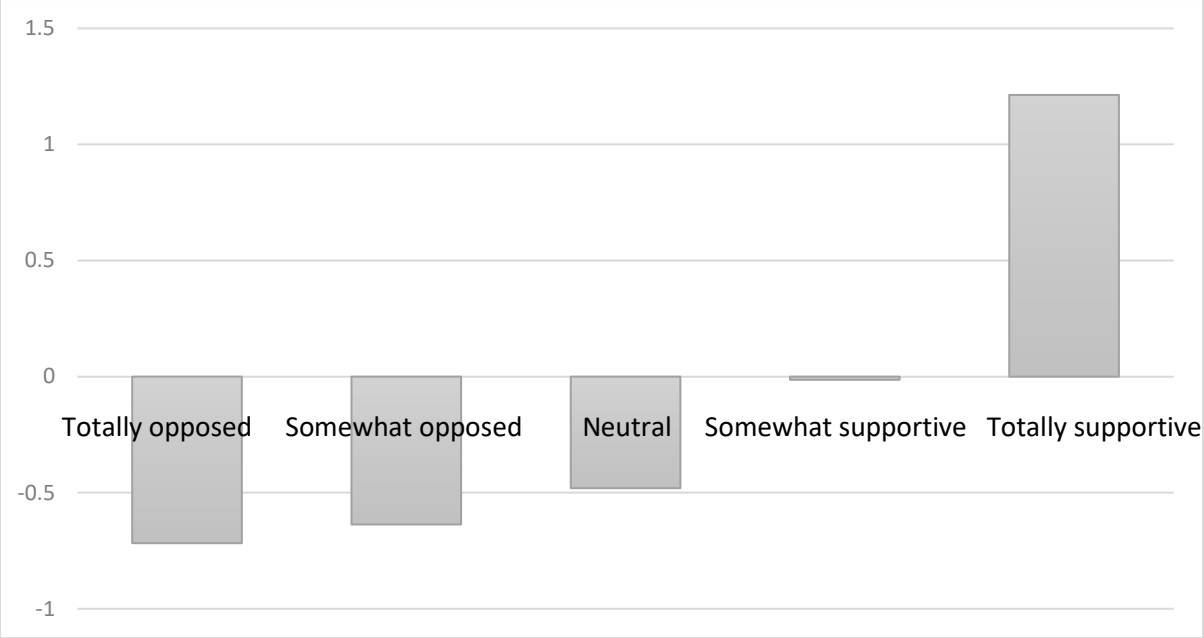

Figure 3: The shift (increase and the decrease) in opinion in all categories of Likert scale at the time of survey compared to when they initially heard about the HT. Above the "0" line indicates an increase swing in opinion while below the "0" line suggest a decreased swing in opinion.

5.3. Identification of type of PMCs on the radiographs; Scores of correct answers

The second part of the questionnaire which consisted of 10 questions (Q 15 - Q 24 see Appendix 1) consisted of random bitewings showing 10 arrowed PMCs (From PMC1 to PMC10) for the participants who had to choose between the options "Hall PMC", "Conventional PMC" or "Don't know" (see Figure 1 and Appendix 1). The correct answer for each bitewing is highlighted in Appendix 1 (Green ticks), Figure 4 and Table 5. A majority of participants were only able to identify the correct answer (i.e., the type of PMC) in five of the bitewings out of a total of 10 bitewings (showing arrowed PMC1-PMC10). The distribution of the correct answers for the questions (Figure 4 and Table 5) showing PMC2, PMC3, PMC5, PMC8 and PMC9 was: n=294 (61.8%), 298 (62.6%), 323 (67.9%), 265 (55.7%) and 317

(66.6%) respectively. With the overall average of correct answer being 4.9 out of 10 [Standard deviation (SD) ± 1.73].

Figure 4: PMC question/response distribution. Proportion of participants who chose the correct type of PMC from the 10 bitewing radiographs showing the PMCs (PMC1 to PMC 10). The red line indicates the 50% mark. HT: Hall Technique. CT: Conventional Technique.

The percentage of participants who got *all* the ten questions correct (i.e., those who scored 10 out of 10) was zero (see Table 6). Therefore, nobody scored 10 out of 10. While the largest proportion (26.9% of the participants, n=128) scored 5 bitewings correctly. The highest correct PMC score recorded was 9, but that was only scored by one participant (0.2%). A total of 2.9% (14 participants) identified all the PMCs in bitewings wrong and scored zero.

Bitewing radiograph with PMC (with the correct answer)	**Correct N (%)**
PMC.1 (CT)	52 (10.9)
PMC.2 (CT)	**294 (61.8)**
PMC.3 (HT)	**298 (62.6)**
PMC.4 (CT)	217 (45.6)
PMC.5 (HT)	**323 (67.9)**
PMC.6 (CT)	160 (33.6)
PMC.7 (CT)	167 (35.1)
PMC.8 (HT)	**265 (55.7)**
PMC.9 (HT)	**317 (66.6)**
PMC.10 (HT)	237 (49.8)

Table 5: Number and proportion of participants who chose the correct type of PMC from the bitewing radiographs (Blue shaded cells). The non-shaded cells are the incorrect responses (below 50%). The correct type of PMC is given in brackets. HT: Hall Technique. CT: Conventional Technique

Correct score distribution

		Frequency	Percent	Valid Percent	Cumulative Percent
PMC score	**.00**	**14**	**2.9**	2.9	2.9
	1.00	11	2.3	2.3	5.3
	2.00	21	4.4	4.4	9.7
	3.00	36	7.6	7.6	17.2
	4.00	78	16.4	16.4	33.6
	5.00	**128**	**26.9**	26.9	60.5
	6.00	117	24.6	24.6	85.1
	7.00	54	11.3	11.3	96.4
	8.00	16	3.4	3.4	99.8
	9.00	**1**	**.2**	.2	100.0
	Total	476	100.0	100.0	

Table 6: Distribution of number of correct PMC scores (out of 10) by participants.

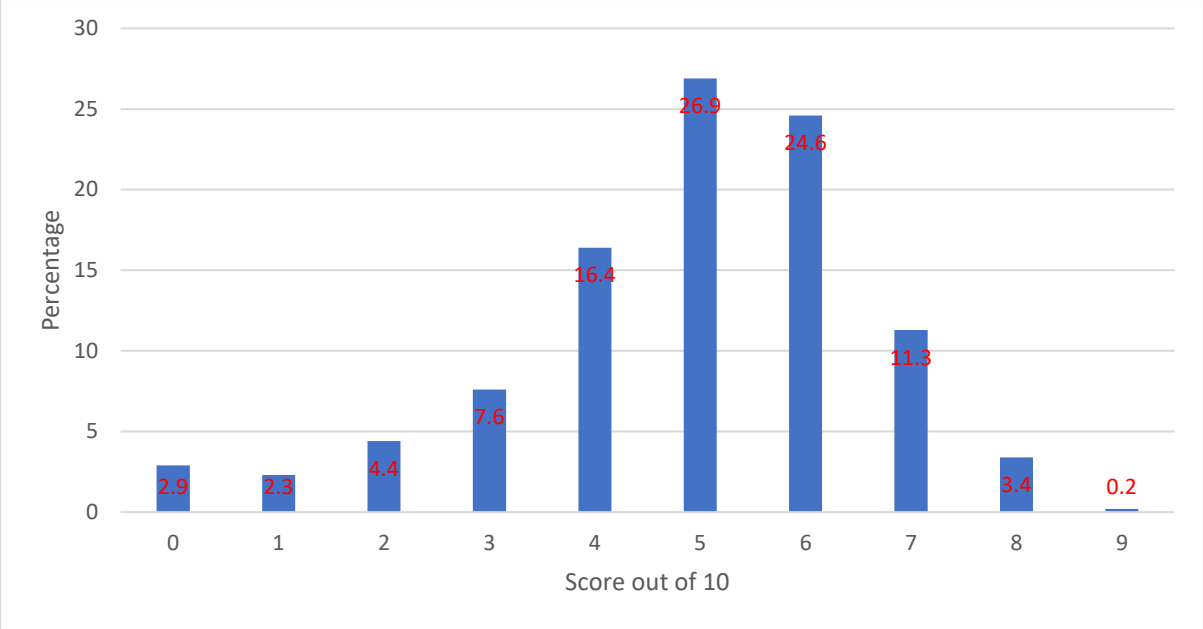

Figure 5: Distribution of participants according to PMC scores.

5.3.1. Sub-analysis of type of PMC identified correctly by the participants

The participants were not informed to the presence of an equal mixture of HT PMCs and conventional PMCs in the survey to reduce bias. As mentioned above, in 5.3; overall, the majority participants managed to identify five out of the 10 PMCs correctly (where the correct response was recorded by >50% of the participants). Four out of those five correctly answered scenarios were HT PMCs. Therefore, the participants managed to identify four out of the five HT PMCs placed in the survey (80% of HT PMCs). The responses for the correct HT PMC questions were n=298, (62.6%); 323(67.9%), 265 (55.7%) and 317 (66.6%) respectively. While on the other hand, the participants managed to recognize only one conventional PMC out of the five conventional PMCs placed in the survey (20% of the conventional PMCs). The response for the only correct conventional PMC question was n=294 (61.8%).

Anyone who managed to identify three or more of the HT PMCs (out of the total of five HT PMCs) in the survey were considered “successful” in identifying HT PMCs. It was noted that

64.9% (n=309) were successful in identifying HT PMCs from the total sample. On the other hand, anyone who managed to identify three or more of the conventional PMCs (out of the total of five conventional PMCs) were considered successful in identifying correctly conventional PMCs. It was noted that only 29% (n=140) were successful in identifying conventional PMCs from the total sample. See Table 7.

Recognising		Frequency	Percent	Valid Percent	Cumulative Percent
>3 **HT** PMCs	Fail	167	35.1	35.1	35.1
	Success	309	**64.9**	64.9	100.0
	Total	476	100.0	100.0	

Recognising		Frequency	Percent	Valid Percent	Cumulative Percent
>3 **CT** PMCs	Fail	336	70.6	70.6	70.6
	Success	140	**29.4**	29.4	100.0
	Total	476	100.0	100.0	

Table 7: Success /failure in identifying > 3 HT or > 3 conventional PMCs

An Odds Ratio of the ability to identify HT PMCs and Conventional PMCs on bitewings was calculated (see Table 8). The Odds Ratio for successfully identifying HT PMCs was 24.857 [CI: 15.059-41.028] while the Odds Ratio for successfully identifying conventional PMCs was 5.361 [CI: 3.089- 9.304]. Thus, it was found that the participants were able to successfully identify HT PMCs on bitewings 4.63 times (almost five-fold) higher than conventional PMCs.

This was very significant (Fischer's exact test p<0.0001).

		95% Confidence Interval	
	Value	Lower	Upper
Odds Ratio for identifying HT PMCs (Fail / Success)	**24.857**	15.059	41.028
For cohort CategScore = Incorrect	6.857	4.936	9.525
For cohort CategScore = Correct	.276	.211	.361
N of Valid Cases	476		

		95% Confidence Interval	
	Value	Lower	Upper
Odds Ratio for identifying conventional PMCs (Fail / Success)	**5.361**	3.089	9.304
For cohort CategScore = Incorrect	3.505	2.207	5.566
For cohort CategScore = Correct	.654	.585	.730
N of Valid Cases	476		

Table 8: Risk estimate/Odd ratio for the Conventional and HT PMCs

5.4. Crosstabulation between the total PMC correct scores and demographic characteristics

These are presented in Table 9. The "country for completion of undergraduate studies" and "country of completion of postgraduate studies" were statistically significantly related to the scores with P value being <0.05. Those studied as an undergraduate (p=0.021) and completed their postgraduate training (p=0.02) in the Mediterranean region scored the highest out of 10 [(5.19 (SD 1.55) and 5.22 (SD 1.52) respectively]. While those in Europe [4.25 (2.18) and 4.43 (2.03)] and America [4.63 (1.94) and 4.7 (1.96)] scored the lowest out of 10. The age and gender and country of practice of the participants were not significantly related to the scores.

Age	**N**	**Mean (SD)**	**P-value**
23-30	109	4.95(0.17)	0.068
31-40	239	5.09(0.99)	
41-50	90	4.44 (0.21)	
51-60	32	4.5 (0.38)	
Gender			
Male	111	5.1 (0.15)	0.193
Female	365	4.83 (0.10)	
Country of practice			
America	100	4.7 (1.96)	0.05
Europe	74	4.32 (2.13)	
Asia	80	5 (1.32)	
Africa	12	4.75 (1.48)	
Mediterranean	210	5.18 (1.55)	
Country for completing undergraduate studies			
America	92	4.63 (1.94)	**0.021**
Europe	76	4.25 (2.18)	
Asia	97	5.02 (1.51)	
Africa	11	5 (1.67)	
Mediterranean	200	5.19 (1.49)	
The country for completing specialization/postgraduate studies			
America	111	4.7 (1.96)	**0.02**
Europe	103	4.43 (2.03)	
Asia	86	5.05 (1.23)	
Africa	10	4.8 (1.52)	
Mediterranean	166	5.22 (1.52)	

Table 9: Correlation between total PMCs scores and demographic characteristics

5.5. Crosstabulation between PMC correct scores and practice status

All values of association between the correct answer and practice status are illustrated in Table 10. The choice of "PMCs for the management of multi-surface carious lesions" (p= 0.005), "number of patients treated using PMCs in a week*"* (p=0.046), and "the participants identification of the HT*"* (p=0.003) were found to be statistically significantly related to the total PMC score. Those who used PMCs always or those who used >30 PMCs per week scored the highest out of 10 [(5.19 (0.12) and (5.14(0.33)] respectively. While those who did not identify the HT, did not use PMCs, or treated any patients with PMCs (per week) scored the lowest [1.5(1.20), 3(0.79) and 3.69 (0.52) respectively] out of 10. On the other hand, their current practice status, professional designation, and their years of experience had no significant relationship with the scores. In addition, neither the frequency of usage of the HT, nor the opinion/ perception towards HT (initially and their opinion at the time of the survey) had any influence on score as they were both not statistically significant.

Currently practicing	**N**	**Mean (SD)**	**P-value**
No	5	4.4 (1.22)	
Yes	471	4.9 (0.79)	0.889
Designation			
Consultant	84	5 (1.71)	
Specialist	329	4.88 (1.73)	0.494
My experience			
< 10	301	4.95 (0.10)	
10-20	2	5 (1)	
21-30	118	4.95 (0.15)	0.273
31-40	39	4.18 (0.35)	
>40	7	5.57 (0.49)	
Metal crown to restore multi-surface carious primary molars in children			
Never	12	3 (0.79)	
Rarely	18	4.06 (0.41)	
Occasionally	51	4.78 (0.25)	***0.005***
Very frequently	218	4.85 (0.12)	
Always	177	5.19 (0.12)	
Number of patients treated using PMC in a week			
None	26	3.69 (0.52)	
1-5	166	4.95 (0.12)	
6-10	151	5 (0.13)	
11-20	78	5.09 (0.20)	***0.046***
20-30	33	4.42 (0.34)	
>30	22	5.14 (0.33)	
Heard and understand Hall Technique			
No	6	1.5 (1.2)	
Yes	470	4.94 (0.08)	***0.003***
When first heard about it			
Totally opposed	22	4.77 (0.43)	
Somewhat opposed	85	4.88 (0.19)	
Neutral	121	4.81 (0.17)	0.862
Somewhat supportive	141	4.83 (0.15)	
Totally supportive	107	5.11 (1.37)	
Now opinion about Hall technique			
Totally opposed	6	5.5 (0.22)	
Somewhat opposed	31	5.03 (0.31)	
Neutral	63	4.52 (0.24)	0.296
Somewhat supportive	139	5 (0.156)	
Totally supportive	237	4.89 (0.11)	
Using / have using the Hall Technique			
Never	102	4.76 (0.19)	
Rarely	93	4.64 (0.19)	
Occasionally	127	5.06 (0.15)	0.287
Very frequently	114	4.89 (0.15)	
Always	40	5.3 (0.23)	

Table 10: Correlation between total PMC scores and clinical status/experience of the participants.

5.6. Perception of differences between HT and conventional PMCs on radiographs

This was the final question in the survey. As shown in Figure 6, when asked if the participants were able to identify any radiographical difference between the PMCs placed using the HT and the conventional method, the majority (67%, n=319) of the PDs responded that they could not find any difference. Therefore, only a third thought there were differences between HT and conventional PMCs on the bitewings overall.

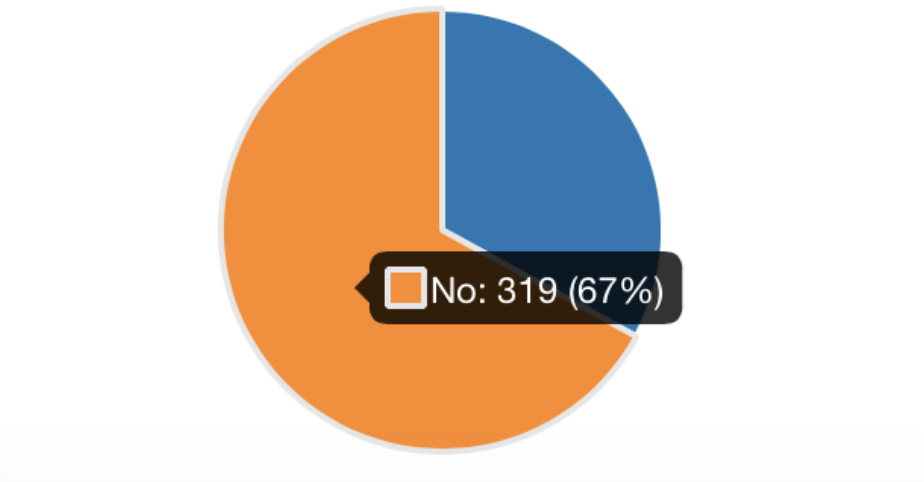

Figure 6: Pie chart depicting the perception of radiographical difference between HT and conventional PMCs (n=476).

When calculating the dependency between the above perception and the actual correct overall scores (out of 10), there was a statistically significant dependent association between them (T-test, $p<0.0001$). Those who perceived that there was a clear radiographic difference between the two types of PMCs on the bitewings had higher scores [5.31(SD 1.22)] out of 10 than those who perceived the opposite [4.68 (SD 1.90)]. See Table 11.

Group Statistics

	Do you think there is a clear radiographic difference between Hall technique PMCs and conventionally prepared PMCs?	N	Mean	Std. Deviation	Std. Error Mean
Correct Overall Score	No	319	**4.6897**	1.90190	.10649
	Yes	157	**5.3121**	1.22398	.09768

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
Score Correct	Equal variances assumed	28.002	**.000**	-3.737	474
	Equal variances not assumed			-4.307	441.326

Table 11: Correlation between opinion regarding the radiographic difference (Q25) with correct answer.

The perception of differences in PMCS on bitewings (from question 25) was cross tabulated against the demographic variables (see Table 12), and against the actual scores for each of the 10 PMC questions (see Table 13). There was statistical significance correlation with the

country of practice (p=0.001), country of studies (undergraduate [p=0.005], and postgraduate [p=0.001]) and years of experience (p=0.037). All Pearson's Chi square.

Based on the aforementioned cross-tabulation, most participants who practiced and studied in Mediterranean region, and those with experience <10 years believed there was a radiographic difference between the two types of PMCs. Age, gender, and designation were not statically significant (See Table 12).

		Do you think there is a clear radiographic difference between HT and CT PMCs?		
		No (%)	Yes (%)	
Overall		**319(67)**	**157(33)**	
Gender	**M**	**75(23.5)**	**36(22.9)**	**0.909**
	F	**244(76.5)**	**121(77.1)**	
Age	**23-30**	**75(23.8)**	**34(21.9)**	**0.702**
	31-40	**156(49.5)**	**83(53.5)**	
	41-60	**60(19)**	**30(19.4)**	
	51-60	**24(7.6)**	**8(5.2)**	
Country of practice	**America**	**78(24.5)**	**22(14)**	**0.001***
	Europe	**58(18.2)**	**16(10.2)**	
	Asia	**46(14.4)**	**34(21.7)**	
	Africa	**5(1.6)**	**7(4.5)**	
	Mediterranean	**132(41.4)**	**78(49.7)**	
Country of UG	**America**	**70(21.9)**	**22(14)**	**0.005***
	Europe	**60(18.8)**	**16(10.2)**	
	Asia	**57(17.9)**	**40(25.5)**	
	Africa	**5(1.6)**	**6(3.6)**	
	Mediterranean	**127(39.5)**	**73(46.3)**	
Country of PG	**America**	**87(27.3)**	**24(15.3)**	**0.001***
	Europe	**75(23.5)**	**28(17.8)**	
	Asia	**47(14.7)**	**39(24.8)**	
	Africa	**4(1.3)**	**6(3.8)**	
	Mediterranean	**106(33.2)**	**60(38.2)**	
Status	**Consultant**	**62(19.5)**	**22(14)**	**0.598**
	Specialist	**251(80.5)**	**130(86)**	
Years of experience	**<10**	**208(65.2)**	**102(65)**	**0.037***
	10-20	**74(23.4)**	**44(28)**	
	21-30	**30(9.4)**	**9(5.7)**	
	31-40	**7(2.2)**	**0(0)**	
	>40	**0(0)**	**2(1.3)**	

Table 12: Correlation between opinion regarding the radiographic difference (Q25) with demographic variables.

		Do you think there is a clear radiographic difference between HT and CT PMCs? No (%)	Yes (%)	
Overall		**319(67)**	**157(33)**	
PMC1 (CT)	Not identified	285(89.3)	139(88.5)	**0.876**
	Identified correctly	35(10.7)	18(11.5)	
PMC2 (CT)	Not identified	132(41.4)	50(31.8)	**0.046***
	Identified correctly	187(58.6)	**107(68.2)**	
PMC3 (HT)	Not identified	144(45.1)	34(21.7)	**0.000***
	Identified correctly	175(54.9)	**123(78.3)**	
PMC4 (CT)	Not identified	171(53.6)	88(56.1)	**0.626**
	Identified correctly	148(46.4)	69(43.9)	
PMC5 (HT)	Not identified	115(36.1)	38(24.2)	**0.009***
	Identified correctly	204(63.9)	**119(75.8)**	
PMC6 (CT)	Not identified	205(64.5)	111(70.7)	**0.18**
	Identified correctly	114(35.7)	46(29.3)	
PMC7 (CT)	Not identified	119(60.5)	**116(73.9)**	**0.004***
	Identified correctly	126(39.5)	41(26.1)	
PMC8 (HT)	Not identified	158(49.5)	53(33.8)	**0.001***
	Identified correctly	161(50.5)	**104(66.2)**	
PMC9 (HT)	Not identified	112(35.1)	47(29.9)	**0.301**
	Identified correctly	207(64.9)	110(70.1)	
PMC10 (HT)	Not identified	179(56.1)	60(38.2)	**0.000***
	Identified correctly	140(43.5)	**97(61.8)**	

Table 13: Cross tabulation between perception of difference of PMCs and the PMC questions. * Fisher's Chi-square. HT: Hall technique. CT: Conventional technique.

When “perception of radiographic differences” was cross tabulated against the ten PMC questions, six PMC questions and responses were found to be very significantly linked ($p<0.005$, Fisher’s Chi square). Most of those participants who thought that there were differences between the HT and conventional PMCs on bitewings, scored correct responses in five PMC questions (PMC2, 3, 5, 8 and 10, $p<0.05$, see Table 13). Out of those five questions, four were related to HT PMCs that were scored correctly, while one was a conventional PMC scored correctly.

There was an additional question related to a conventional PMC (PMC7) where a majority did not identify the correct PMC on the bitewing, despite perceiving the existence of radiographic differences between both crowns. ($p=0.004$, Fisher’s Chi square).

6. DISCUSSION

This project studied an aspect of a very topical issue being addressed in the contemporary pediatric dentistry circles today; i.e. the Hall Technique[133]. This very successful method both clinically and radiographically, had been studied immensely and is gaining more support amongst PDs[71, 94, 134]. The present study related to a published opinion that addressed concerns that HT PMCs are substandard, because they are oversized, and poorly adapted crowns[135]. The findings of this study suggested that PDs support the HT and it also highlighted that they perceive conventional and HT PMCs to be similar on radiographs. The present research suggested that PDs, experienced in assessing bitewing radiographs in children, were unable to clearly identify *all* types of PMCs on such radiographs. However, their actual ability to identify HT PMCs on bitewings was much higher than that of conventional PMCs.

The HT is a minimally invasive dental procedure (or MID)[28]. Contemporary guidelines have noted the importance of advocating MID wherever possible, especially with the current global pandemic of Covid-19[28], and under that umbrella, the use of HT has been strongly recommended wherever indicated in clinical practice. This highlights the importance of HT in pediatric dentistry today. When looking at the data available, a study from UK reported that about 90% of the PDs deemed that HT PMCs were suitable for practice[134]. While, the study by Hussein *et al.* [7] concluded that although majority of the PDs across the globe, recognized HT and just slightly more than 50% of them used it, many did not; stating lack of training, perception as substandard dentistry and lack of evidence as reasons. This research aimed to contribute and complement an increasing number of HT related research globally.

The response rate was around 10% which is in the range of recently published studies[136-138]. However, we exceeded the calculated sample size which could have been due to the ease of

online accessibility and being conducted during the time of pandemic when online was the only accessible medium across the world.

6.1. Why is this study important?

The credit for the idea behind this project goes to a past postgraduate resident (Dr Zach Percival) in the United States (US) who presented a poster in an AAPD meeting under the title "*Radiographic Adaptation of Prefabricated Stainless-Steel Crowns - A Pilot Study*" at the AAPD annual conference in Honolulu, Hawaii, US[10] in 2018. However, despite attempts to search for the above poster's published results on databases (such as Medline, PubMed, Scopus, and Google) to the author's knowledge, only the concept of the poster presentation was published (i.e., no published results). Thus, within the context of the HT being considered an oversized PMC, this study was set out with the aim of assessing PDs' ability to identify the radiographical difference between the PMCs that were placed using the HT versus the conventional technique.

Although several studies have reported evidence validating the HT, the question regarding the fit of the PMC[5] using HT has been raised[139], as mentioned in the literature review. This had been reported as one of the many reasons that discourages PDs from using HT in their practice[6]. Very little was found in the literature regarding the assessment of the size and fit of the PMC placed using HT[100], with only one unpublished poster study, mentioned above, assessing if the PDs of various experience levels were able to identify the radiographic difference between the PMCs placed using HT to that of conventional method. This study is important in bridging the gap between PDs' practice and the HT, by providing an answer to the controversial questions raised regarding the fit of the PMCs using the HT.

6.2. Usage of PMCs and their perception towards HT

This study showed that there is an increased support in the use of the HT. Out of the 476 responses that we had received, almost all the PDs (98.7%) knew about the HT which was in line with Hussein *et al.,* 2020[7]. Most of the participants were specialists who obviously use PMCs frequently in the management of multi-surface carious lesions, and interestingly a majority (78.6%) used the HT, which was higher than the 18.6% and 50.6% reported by Hussein *et al.,* in 2017 [140] and 2020[7] respectively, but is lower than the 96% reported by Roberts *et al.* in 2018[134]. This suggested an increase in HT popularity over time. This was specifically examined in the current project as it demonstrated a clear shift among the respondents in regard to their own perception towards the HT over time. With the majority of them (79%) being supportive towards the HT, (29.6%) of the participants who were initially not supportive about the HT (when they first heard about the HT) had changed their opinion (now) during the time of survey. The change to support the HT's use was 11 times more likely than to remain non-supportive over time. Indeed, current pediatric dentistry guidelines cannot ignore the HT any longer. This has been reflected in the most recent AAPD guidelines which, in line with its increased popularity, added the HT to the "pediatric dentistry restorative guidelines", which the AAPD publishes annually[141].

6.3. Adaptation of PMC fitted using the HT

In spite of the higher success rate of the HT being reported repeatedly validating the use of HT[142], the questions raised regarding the marginal fit and the adaptation of PMC[5] cannot be ignored, because it had discourages some practitioners from using the HT. Indeed, online forum debates in the AAPD circles frequently highlighted this issue (personal observation). The reluctancy to use HT by some may be due to a perception that larger crowns and over-extending margins of HT PMCs are associated with leakage (proven *in vitro* by Erdemci *et al.* in 2014)[100]

and unproven concerns about dental and periodontal clinical pathology. However, till date, and to the best of the authors knowledge, no clinical and radiographic success rate of the HT below 90% had ever been reported.

Nevertheless, the oversized crown issue required addressing. Because the HT uses a PMC with no crown preparation, it is the assumed that PMCs are larger than the teeth they are seated on. Moreover, stainless-steel PMCs are known to be very flexible[143] and can spring over minor contours because of this flexibility[144]. Thus, one can assume that the PMC fits a primary molar by either one or both of two mechanisms: a larger than tooth PMC, or a similar-to-tooth sized PMC that flexes and fits. Especially that the thickness of these flexible PMCs is between 0.2 to 0.7mm, a very negligible thickness[145].

This study assessed if PDs could radiographically identify the difference between the PMCs fitted using the HT and to that using the conventional method by providing 10 bitewings, showing PMCs. Remarkably, a majority of the participants were able to identify the correct answer (i.e., the type of PMC) in only five out of ten bitewings. On initial analysis, this indicated a clear general difficulty in recognizing PMC type on bitewing radiographs. However, four out of the five correctly identified radiographs were HT PMCs. On further analysis, it was noted that the majority of the participants (64.9%) managed to identify three or more HT PMCs out of the five in the bitewings provided in the survey. This result is somewhat counterintuitive, that despite the fact that the majority of the participants could identify only five out of the ten bitewings with correct type of PMCs, four out of five were HT PMCs. Overall, it appeared that they were confused in detecting conventional PMCs, which could be explained by the fact that some were relatively larger than expected, presumably mimicking HT PMCs. This was further analyzed, and it was found that PDs had five 5 times more of a chance to identify HT PMCs than conventional PMCs. The latter observation suggested that indeed, the HT PMCs appeared larger on bitewings than their conventional

counterparts. This also suggested that HT PMCs, visible in the radiographs, were larger than the teeth they were seated on. However, the same could not be said about the ability to detect conventional PMCs.

A surprising finding was the difference between perception and actual ability to detect radiographic differences. When questioned, the majority of the PDs perceived the lack of radiographic differences between the two PMC type. This opposed the view point of Croll *et al.*, published in Pediatric Dentistry in 2016 [139], that HT PMCs are seen as over-sized poor fitting crowns. The perception may be due the fact that differences in actual measurable units (such as millimeters) on bitewings are small and negligible as the thickness of the PMCs were. In addition, that many radiologic factors can affect the ability to accurately detect the objects on bitewings; exposure parameters, type of image receptor, image processing, display system, viewing conditions and visual illusions[146].

Although studies[147, 148] have shown that bitewings have been used to determine crown and tooth size, the ability of the human eye to detect small changes on dental radiographs has been the subject of many recent research projects[149, 150], to the extent of involving artificial intelligence neural networks to improve detection. Nevertheless, the ability of some participants in the present study to detect HT PMCs more than conventional PMCs may be due to the fact that the PMCs appeared larger than the teeth they covered and appeared to have over hanging margins. Although our study avoided the reference to "overhanging margins" to avoid influencing the participants' choice, this warrants further research. For example, comparing crimped PMCs to none crimped PMCs, to test the ability of the human (dentist) eye to detect a difference, if any, may be a suitable research topic. In this study, we used horizontal bitewings, to assess PMCs in children[151]. Research has shown that ability to detect dental differences on bitewings improved when vertical bitewings were used in adults[152] but their use is impracticable in children. Interestingly, those participants who believed that there was a clear

radiographic difference between the two types of PMCs on the bitewings scored higher than the ones who believed there was no radiographic difference, and this was statistically significant. This indicated that the ability to detect differences, in this subgroup, matched their belief and perception that a real difference existed. Research has shown the ability to detect primary molar crown dimensions on bitewings is a valid method of research[153]. The lack of gap between perceived and actual ability to detect differences (and thus scoring better scores) was related to increased number of child patients treated with PMCs per week (>30) and signified high self-confidence in this subgroup that may have stemmed from more practical experience. Thus, those who had more PMC experience in children believed in the existence of differences between PMC types and scored better scores than the majority who did not believe there were differences between the two types on bitewings.

6.4. Correlation between correct PMC response and demographic characteristics

Although we targeted a global audience, the majority of the participants practiced in the Eastern Mediterranean region, followed by America and Europe. The most interesting finding was the correlation between PDs' country of practice (P-value=0.05), country where they completed their undergraduate studies (P-value=0.021), and country where they completed their postgraduation studies (P-value=0.02) and the higher scores (out of 10) in response to seeing the 10 bitewings. The highest mean score of the correct answer came from the PDs who were practicing or had their under- and post- graduate studies completed from Eastern Mediterranean region, followed by Asia. This was a surprising finding as the HT is not included in most undergraduate and many postgraduate pediatric dentistry curricula in the region to our understanding (unpublished data from personal conversations with students and faculty from that region)[76, 154, 155], with the exception of the UAE for the latter. No real explanation can be offered for this, but this group was the largest in the present study. Dental caries in children in

the Eastern Mediterranean region has been recently reported[156] as one of the highest in the world, whether high or low socio-economic conditions. Thus, PDs in the East Mediterranean region may have been exposed to, and have more experience in dealing with, primary molar caries than other regions. Several HT related research projects were published in the Eastern Mediterranean, leading to a potential upsurge in the use of HT[157], especially those nations with limited resources, which may had influenced this study's research[142], as the switch from conventional PMCs to HT PMCs was a recent change, but this is conjecture only with no hard-proof evidence. On the other hand, this point may be explained by the observation that Eastern Mediterranean PDs had traditionally used conventional PMCs, for decades and it may be conjectured that they knew how these PMCs looked like on radiographs and were able to identify the different (Hall) PMCs easier than those who do more Hall PMCs in Europe. This may be because some countries in the region, like the UAE, were introduced to the HT as recent as 2014[157]. In addition, some studies have shown high knowledge levels in dentists in the Eastern Mediterranean region in relation to contemporary matters such as Covid-19, demonstrating an increase drive to improve dental knowledge and practice in the region[132]. On the other hand, a finding that the lowest mean scores came from PDs in Europe, was contrary to the expectation. As Europe is considered the birthplace of the HT, and the technique had been widely used (for example since the year 2000 in the UK[7]) and had been incorporated in European undergraduate and postgraduate curricula since 2012[74, 158]. Nevertheless, the authors of this research acknowledge that the sample size in this study was unrepresentative of the regions surveyed, as the PDs representing from each region were not distributed equally, thus real comparisons per region were difficult to clarify.

Some notable correlations were the practice status among the participants. PDs who used PMCs, had the highest mean score of the correct answer (out of 10). This indicated that practice improved skills. Supporting this result was the statistical significance found between the

number of patients treated using PMCs per week to their identification of choosing the correct PMCs in the bitewings provided. As highlighted above, participants who treated more than 30 patients using PMC per week scored better while identifying the correct PMCs in the bitewings. As expected, a statistical significance among the participants who have heard and understood the HT was noted. Although, PDs who were consultants and who had more than 40 years of experience or those who have used the HT frequently were found to had higher mean score, they were not statistically significant. Thus, a variety of demographic factors played a role in the scores of the correct PMC type.

6.5. Are PMCs placed using HT oversized?

Many PMCs are fitted on a primary molar, whether by the HT or conventional, by crimping the margins of the PMCs for better adaptation. This may affect the appearance of the marginal adaptation of a PMC and its visibility on the radiograph. However, this was not assessed as a variable in the current survey. The PDs surveyed in this study were able to identify and recognize that there were PMCs in the radiographs, as this is a basic skill. However, this study did not measure in units the sizes of crowns nor the gap, if any between the PMC and the tooth. This study assessed visual perception of PDs and their ability to detect these PMCs. Nevertheless, the results were disappointing. With the overall average of correct score being 4.9 out of 10, the majority of the PDs were able to recognize only 5 out of 10 bitewings correctly. This observation may initially appear to support the hypothesis that there is no difference in the radiographic appearance of the PMCs whether placed using the HT or the conventional technique as reported by pediatric dentists. Nevertheless, the sub-analysis disproved that. As mentioned above, it is intriguing to note that out of the five correct PMCs that were chosen by the majority, 4 of them were HT PMCs, while only one was a conventional PMC. This suggested that the participant's ability to identify HT PMCs was higher

comparatively, while they had confusion in detecting conventional PMCs. Along with the other observations, such as the majority of the PDs expressing there was no radiographical difference between the PMCs placed using the HT to the conventional. It was interesting to note that there was a significant correlation between the participants who believed there was a radiographic difference (although a minority of them) between the type of PMC and choosing the correct answer, which helped the authors assume that there might be slight overhanging margins with the PMCs placed using the HT, as the correct answer chosen by the majority consisted of 80% HTPMCs. Finally, several questions arise, which this study had not answered; if HT PMCs were larger on bitewings, and PDs were able to notice them anyway; would that make any difference? Would that reduce the quality of the HT treatment? Will it lead to lower success rates? The authors' presumed answers to these questions would be no, but they warrant further research. Therefore, the proposed null hypothesis was rejected. PDs were able to identify more HT PMCs on bitewings than conventional PMCs on bitewings. There was a difference in the radiographic appearance of the PMCs whether placed using the HT or the conventional technique as reported by pediatric dentists.

6.6. Limitations of the study

1. Assessment of this study was done utilizing an online questionnaire which contained radiographs, and this could be subjective, which may involve cognitive bias. Viewing conditions may vary from person to person /device to device.

2. Although bitewings provided in the survey were Grade 1 (or) Grade 2 (with no overlapping) quality, no standardization was done, as they were randomly chosen which had been taken for the routine diagnostic purpose sourced from various pediatric dentists at the hospital.

3. Although the sample size exceeded the power calculation, the authors acknowledge that the sample size in this study is unrepresentative of the global regions surveyed, as the PDs representing from each region was not distributed equally.

4. As the radiographs were sourced from the same dental hospital, sourcing radiographs from different clinics, showing HT placed by different practitioners both specialists and GDPs (General dental practitioner) at different practices could be assessed for future.

7. CONCLUSIONS

In the studied sample of pediatric dentists from around the world, and with respect to the limitations, it can be concluded that:

- In general, PDs identified the PMC type in only half of bitewing radiographs. Identification was associated with various demographic variables.
- Most of the correctly identified PMCs were HT PMCs.
- There were difficulties in identifying conventional PMCs on radiographs.
- Although, most of the surveyed PDs perceived that there was no clear radiographic difference between HT and conventional PMCs on bitewings radiographs, the chance of them recognizing HT PMCs on bitewings was almost five times higher than conventional PMCs.
- There was a clear supportive shift (11-fold) in PDs opinion over time, in favor of the use of the HT.

7.1. Recommendations

- The need for future studies using higher level of evidence is required. An example would be to compare crimped and non-crimped PMCs (of both types) to assess the ability of PDs to identify which is which on bitewings.
- Need for larger sample with equally distributed PDs from each region is recommended.
- Furthermore, combining radiographical assessment with clinical assessment of PMCs by PDs may provide more data and hence take forthcomings studies to a higher level.

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9. APPENDICES

Appendix I

Hall vs Conventional Preformed Metal Crowns: Radiographic Identification

Section 1

Consent form

You are invited to take part in a research questionnaire about the 'Hall versus conventional crowns: Radiographic identification by pediatric dentists'.

I am a postgradaute dental researcher at Mohammed Bin Rashid University of Medicine and Health Sciences in Dubai, UAE. The team I am part of would like to survey the opinions of specialist pediatric dentists with regards to restored primary molars in children and would be grateful for your expert opinion.

The survey should take no more than 5 minutes of your time. It is confidential and anonymous; no identifying personal details will be taken. If you are a specialist pediatric dentist and would like to participate, kindly proceed as below.

If you have any questions about the research study, please contact sahaana.mohanraja@residents.mbru.ac.ae
Clicking "I agree" indicates that you are a pediatric dentist, you have read the information and you give your consent to participate in this survey.

1

- I agree
- I don't agree

Section 2

The survey

Demographics

2

My age is between *

- 23-30
- 31-40
- 41-50
- 51-60
- 61 +

3

My gender is *

- Male
- Female

4

My country of practice is *

Enter your answer

5

The country I completed my undergraduate studies was *

Enter your answer

6

The country I completed my specialization/postgraduate studies was *

Enter your answer

7

Currently practicing pediatric dentistry ? *

- Yes
- No

8

I am a *

- Specialist
- Consultant
- Other

9

My years of experience as a specialist are *

- <10
- 10-20
- 21-30
- 31-40
- >40

10

I use preformed metal crowns (PMCs- otherwise known as stainless steel crowns) to restore multi surface carious primary molars in children *

- Never
- Rarely
- Occasionally
- Very frequently
- Always

11

The number of patients I treat using PMCs in a week is in the range of : *

- None
- 1-5
- 6-10
- 11-20
- 21-30
- >30

12

I have heard of, and understand, the Hall technique ? *

- Yes
- No

13

My opinion of the Hall technique *

	totally supportive	somewhat supportive	neutral	somewhat opposed	totally opposed
When I first heard about it	○	○	○	○	○
Now is	○	○	○	○	○

14

I use/have used the Hall technique in my practice? *

- ○ Never
- ○ Rarely
- ○ Occasionally
- ○ Very frequently
- ○ Always

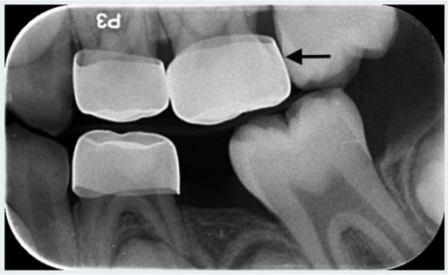
Section 3 ...

Radiographs

The following is a random series of bitewing radiographs. Please see the marked crowned primary molar tooth (highlighted by an the arrow pointing towards the tooth) and identify if you think it is a Hall PMC or conventionally placed PMC. If you are not sure or you can't differentiate, you can choose the option "Don't know".

15

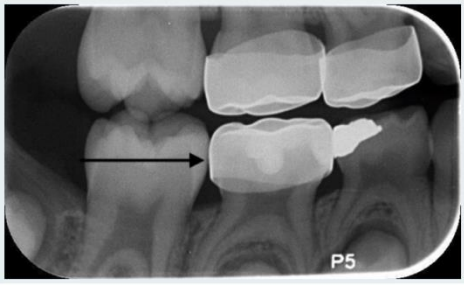
The arrowed PMC is a ... *



- Hall PMC
- ✓ Conventionally prepared PMC
- Don't know

16

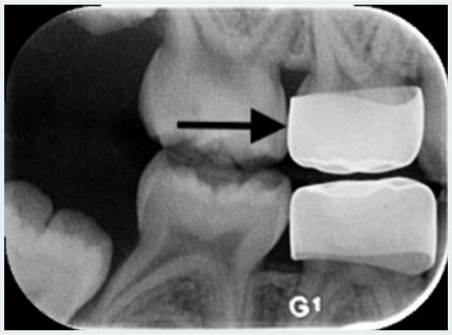
The arrowed PMC is a ... *



- Hall PMC
- ✓ Conventionally prepared PMC
- Don't know

17

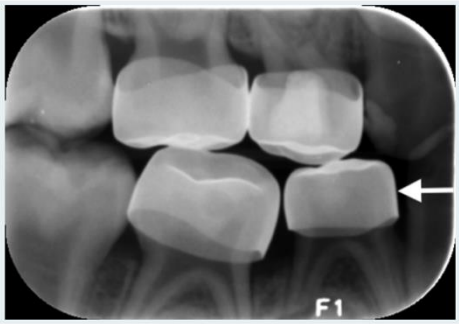
The arrowed PMC is a ... *



- [x] Hall PMC
- [ ] Conventionally prepared PMC
- [ ] Don't know

18

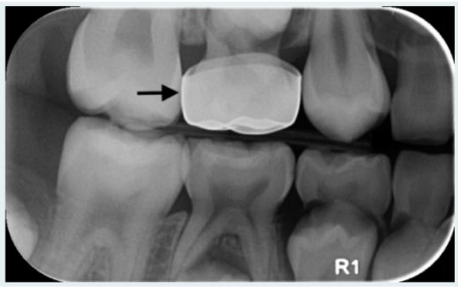
The arrowed PMC is a ... *



- [ ] Hall PMC
- [x] Conventionally prepared PMC
- [ ] Don't know

19

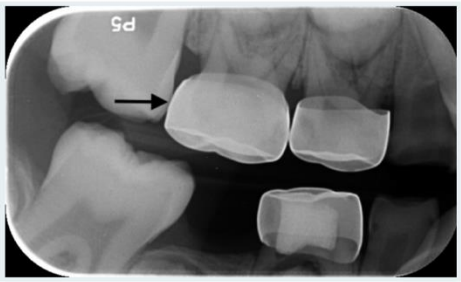
The arrowed PMC is a ... *



- [x] Hall PMC
- [ ] Conventionally prepared PMC
- [ ] Don't know

20

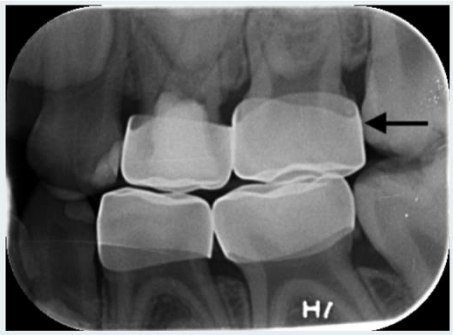
The arrowed PMC is a ... *



- Hall PMC
- ✓ Conventionally prepared PMC
- Don't know

21

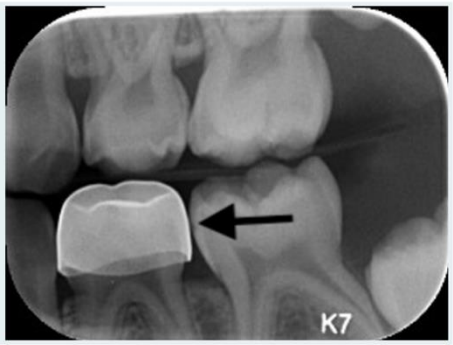
The arrowed PMC is a ... *



- Hall PMC
- ✓ Conventionally prepared PMC
- Don't know

22

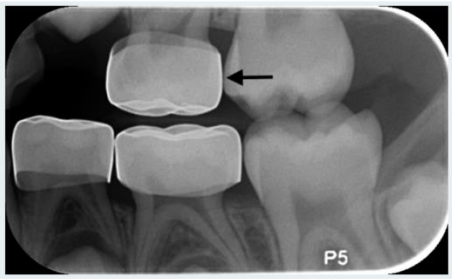
The arrowed PMC is a ... *



- ✓ Hall PMC
- Conventionally prepared PMC
- Don't know

23

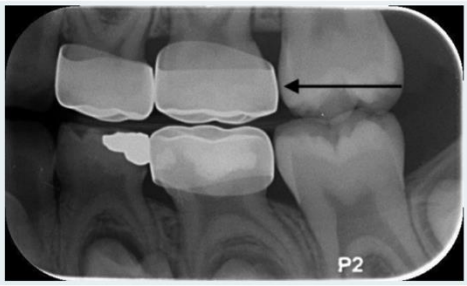
The arrowed PMC is a ... *



- [x] Hall PMC
- [ ] Conventionally prepared PMC
- [ ] Don't know

24

The arrowed PMC is a ... *



- [x] Hall PMC
- [ ] Conventionally prepared PMC
- [ ] Don't know

25

Do you think there is a clear radiographic difference between Hall technique PMCs and conventionally prepared PMCs? *

- [ ] Yes
- [ ] No

Appendix II

MBRU
جامعة محمد بن راشد للطب والعلوم الصحية
MOHAMMED BIN RASHID UNIVERSITY OF MEDICINE AND HEALTH SCIENCES

26 November 2019

Dr Sahaana Mohanraja
Pediatric Dentistry Resident
HBMCDM

RE: MBRU-IRB-2019-025

Dear Dr Sahaana,

Thank you for submitting to the Board the study titled "Hall versus conventional preformed metal crowns: Radiographic Identification by Pediatric Dentists" for exempt review. The Board has reviewed the same at its meeting of November 26, 2019 and has approved the application. Please note that all patient identifiers on x-rays should be removed before they are sent to the study subjects.

The study can now commence. Any change in protocol must be notified to the Board.

For any questions, please contact the Institutional Review Board irb@mbru.ac.ae.

Thank you for your interest in MBRU's IRB.

Yours Sincerely,

Essa Kazim, FRCS
Chairman, MBRU-IRB

لجنة أخلاقيات البحوث
INSTITUTIONAL REVIEW BOARD

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