Evaluation of Changes in the Occlusion and Occlusal Vertical Dimension in Children Following the Placement of Preformed Metal Crowns Using the Hall Technique

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Objectives: *To evaluate the time taken and the mechanism through which the occlusion settles following the placement of a preformed metal crown (PMC) using the Hall technique. The secondary objective was to assess any temporo mandibular joint dysfunction (TMD) resulting from the Hall technique through a questionnaire.* ***Study Design:*** *44 children fulfilling the inclusion criteria were evaluated for changes in overbite and occlusal vertical dimension (OVD) following the placement of preformed metal crowns (PMCs) using the Hall technique. The overbite and OVD measurements were taken before treatment, immediately post treatment, then at one, two, three and four weeks post treatment. After four weeks, a questionnaire recorded the occurrence of any signs or symptoms of TMD.* ***Results:*** *At the fourth week, the overbite measurement did not show a statistically significant difference (p value= 0.58) compared to baseline values indicating that the occlusion settled by the fourth week. By the third week the OVD values obtained did not show a significant difference compared to the baseline (p value= 0.42) indicating that the OVD had been restored. The questionnaire provided at the end of four weeks showed negative response for signs and symptoms of TMD in all the children.* ***Conclusion:*** *Any changes in occlusion following the placement of a Hall crown settles in four weeks. The OVD settles three weeks post placement implying that extrusion of teeth do not play a role in settling of the occlusion. The children do not develop any signs or symptoms of TMD post a Hall crown.*

Keywords: *Occlusion, TMD, Hall Crown, Preformed Metal Crown, Stainless Steel Crown*

INTRODUCTION

Management of carious primary molars has evolved through the years. Earlier surgical approaches involving complete removal of carious dentine are now being challenged by less invasive biological approaches like non-restorative caries treatment (NRCT) and the Hall technique. These contemporary techniques involving alteration of the biofilm to arrest the carious lesions[1] have shown favorable outcomes compared to conventional techniques[2-4].

The Hall technique of carious tissue management in primary molars named after Norna Hall, involves cementing a preformed metal crown (PMC) on carious primary molars using glass ionomer cement without any caries removal[5,6]. Managing a carious tooth without removing the carious tissue may seem counterintuitive[5, 7]. However, recent studies using the Hall technique showed favorable outcomes for primary teeth compared to conventional restorative measures[2, 7-9] This technique is effective as it manipulates the plaque environment by separating it from the substrates (essentially nutrition) it would normally receive from the oral environment. Sealing-in the caries decreases the cariogenicity of the biofilm by limiting the supply of carbohydrates and oxygen thereby slowing down or arresting the carious process[5, 6]. Studies have shown a high

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degree of acceptance among children, parents and dentists for the placement of a PMC using the Hall technique [9-12].

Sufficient occlusal and proximal reduction allow the crown to be seated beyond the maximum bulbosity of the tooth in the conventional technique of placing a PMC[13] Hence, an occlusal discrepancy is avoided. As occlusal reduction is not done in the Hall technique, a discrepancy in the occlusion and occlusal vertical dimension (OVD) is expected.[9, 14, 15]. A study by Innes et al[9] suggested that the occlusion in children re-establishes within a few weeks following placement of a Hall crown. Another study by van der Zee *et al* [14] showed settling of occlusion in children following the placement of a Hall crown in 15-30 days. There is no consensus in literature on the time frame within which the occlusion settles following cementation of the Hall crown.

According to Dahl concept, a large increase in OVD is compensated by intrusion of the restored tooth and its antagonist, re-eruption of other teeth in the arch or a combination of both.[16, 17-.]The compensatory mechanism through which the occlusion settles following the Hall crown placement needs to be investigated further.

Another concern regarding the Hall technique is whether the intermediate increase in OVD predispose children to temporo mandibular joint dysfunction[18, 19] (TMD). This aspect has not been formally investigated in any of the earlier studies on Hall crowns. Available literature on the role of occlusal interference in causing TMD in children is also inconclusive[20-21].

Hence, the aim of the present study was to observe the timeframe and the compensation mechanism of occlusal settlement following the placement of a Hall crown. The secondary aim of the study was to investigate if any of the children showed signs and symptoms of TMD.

MATERIALS AND METHOD

This was a prospective clinical study conducted in Department of Paedodontics and Preventive Dentistry, Manipal College of Dental Sciences, Mangalore, India following approval from the institutional ethics committee.

Sample size was calculated using G*Power 3.1.2 software (Version 3.1.9.4,Heinrich Heine Universitat, Dusseldorf, Germany) The effect size was set at 0.3, with 99% confidence interval and 90% power. Therefore, the final sample size for the study was 44.

Parents of the patients were informed about the procedure using a patient information sheet following which their informed consent was obtained.

The Inclusion Criteria for the study were

- Class I and class II carious lesions extending to dentin (ICDAS 4 and 5 [22])
- Primary first molars with at least two third of roots present radiographically.
- The Exclusion Criteria were
- Teeth with signs or symptoms of irreversible pulpal pathology.
- Children with any intercanine relation other than Class I
- Children with systemic conditions requiring special dental considerations.

51 patients who visited the department of Paedodontics and Preventive dentistry for routine dental treatment took part in the study. One carious first primary molar in each patient was allocated for intervention (Hall technique) after clinical and radiological assessment. An initial baseline measurement of OVD and overbite was done for each patient. This served as a control against which future values were compared.

Measurement of OVD [23-25]

The tip of nose (N) and chin (C) in the midline were taken as reference points and were marked with a marker pen. For each patient, the distance of N from the vermillion border of upper lip and the distance of C from the vermillion border of lower lip were measured on the midline to reproduce these points in the recall visits. The measurement of the distance from point N to the vermillion border of the upper lip is shown in Fig 1 A and from point C to the vermillion border of the lower lip is shown in Fig 1B. The patients were asked to bite on their back teeth several times to confirm the reproducibility of occlusion in maximum intercuspation position (MIP).[15] Once this was established, the OVD was determined by measuring the distance between these reference points with a modified digital vernier caliper[23,24] (Altraco Inc., California, USA). The measurement of the OVD is shown in Fig 1 C. Each measurement was taken three times and a minimum of 60 seconds was ensured between each reading. The mean of the three readings was taken as the final measurement.

Figure 1: A. Measurement of distance from point N to vermillion border of upper lip. B. Measurement of distance from point C to vermillion border of lower lip. C. Measurement of OVD

Measurement of Overbite[14]

Similar to the measurement of OVD, patients were asked to bite on their back teeth several times to confirm the reproducibility of occlusion in MIP. When the upper and lower teeth were occluded in maximum intercuspation the most prominent incisal point of the left maxillary cuspid was noted and marked on the lower cuspid. The most incisal point of the maxillary cuspid marked on the mandibular cuspid is shown in Fig 2 A**.** The vertical distance between the marked point and the most prominent incisal point of the mandibular cuspid was then measured with a Williams probe (SS White Inc., New Jersey, USA). The measurement of overbite from the marked point to the incisal edge of the mandibular cuspid is shown in Fig 2 B. This was scored as the overbite. As with determination of OVD, each measurement was taken three times and the mean was calculated. If measuring the overbite at the left cuspid was not possible, it was carried out at the right cuspid.

The OVD and overbite were recorded pre operatively, immediately after crown placement and once a week for one month (four times) after placement of the PMC. The post-operative values after each week were then compared with initial pre-operative values.

Figure 2: A. Most incisal point of maxillary cuspid marked on the mandibular cuspid. Measurement of overbite from the marked point to the incisal edge of mandibular cuspid

The Hall crowns were placed as described by Innes et al[5]. The principal investigator placed the PMCs using the Hall technique and measured the overbite and OVD . As a secondary aim of the study, a questionnaire[26] was provided to assess the temporo mandibular joint (TMJ) for any symptoms of TMD following treatment, which was to be filled by either the patient or the parent at the end of 4 weeks.

Statistical analysis was carried out using SPSS 20.0 version (IBM Corporation, Chicago, USA)

Descriptive statistics was carried out to monitor the changes in overbite and OVD during the four-week recall period. Repeated measures of ANOVA with posthoc Bonferroni's test was applied to check the statistical significance of changes in the overbite and the OVD at the immediate post-operative period and at the first, second, third and fourth week. The level of significance was set at less than or equal to 0.05.

RESULTS

In the present study, 51 children were included of which seven children did not turn up for the follow up visits. Therefore, at the end of 1 month 44 children who were present for all the follow up visits were included in the study. The subjects belonged to the age group of four to nine years with a mean age of 6.57 years. The standard deviation to the mean age of the sample was 1.388. Among the 44 children, 26 were males (59.1%) and 18 were females (40.9%)

Descriptive statistics and comparison of mean OVD values recorded at baseline, immediate post treatment and at one, two three and four weeks is presented in table 1. On comparing the post treatment values with the baseline, there was a statistically significant difference until the second week. In the third week, the OVD values did not show a significant difference when compared to the baseline. ($p < 0.001$) indicating that the OVD had been restored. At the fourth week, the OVD value decreased further compared to the baseline value. though the difference was statistically insignificant This difference was statistically significant ($p < 0.001$)

Descriptive statistics and comparison of mean overbite values recorded at baseline, immediate post treatment and at one, two three and four weeks is presented in table 2. On comparing the post treatment values with the baseline, there was significant difference in the values till the third week. At the fourth week the overbite measurement did not show a statistically significant difference ($p < 0.001$) indicating that the occlusion settled at the fourth week.

The questionnaire[26] provided at the end of four weeks to assess the occurrence of TMD as a secondary aim of the study showed negative response for signs and symptoms of TMD (pain in the lower jaw and temple, headache in temple area, stiffness and pain of TMJ on waking up) in all the 44 children.

Table 1: Descriptive statistics and comparison of mean OVD values recorded at baseline, immediate post treatment and at one, two three and four weeks using repeated measures of ANOVA with posthoc Bonferroni's test

		N	Mean	Std. Deviation	F value	p value	Mean difference from baseline	standard error	p value
	Baseline	44	55.87	2.90					
	Immediate post treatment	44	56.90	2.85			-1.034	0.045	<0.001
	1 week	44	56.56	2.80			-0.689	0.062	<0.001
	2 weeks	44	56.12	2.79			-0.253	0.051	<0.001
	3 weeks	44	55.89	2.86			-0.024	0.03	1
OVD	4 weeks	44	55.83	2.92	186.728	<0.001	0.032	0.015	0.559

Table 2: Descriptive statistics and comparison of mean overbite values recorded at baseline, immediate post treatment and at one, two three and four weeks using repeated measures of ANOVA with posthoc Bonferroni's test

		N	Mean	Std. Deviation	F value	p value	Mean difference from baseline	standard error	p value
	Baseline	44	2.54	0.77					
	Immediate post treatment	44	1.56	0.68			.986*	0.055	<0.001
	1 week	44	1.83	0.75			.716*	0.059	<0.001
	2 weeks	44	2.19	0.77			.352*	0.058	<0.001
	3 weeks	44	2.46	0.74			0.082	0.031	0.175
Overbite	4 weeks	44	2.53	0.76	147.035	<0.001	0.014	0.025	1

DISCUSSION

As the Hall Technique does not involve any occlusal reduction of teeth, placing a Hall crown will cause an increase in the OVD with premature contacts[9, 14]. This study explored the timeframe within which it resolves and the compensation mechanism involved.

Van der Zee *et al* [14] reported equilibration of overbite 30 days following placement of the Hall crown. The present study also reported approximately a similar time frame. However, there were several limitations in the Van der Zee et al study. The study evaluated patients at long intervals of 15 and 30 days. In addition, the number of Hall crowns placed in the same child ranged from one to four and sometimes crowns were placed on opposing tooth. This could have caused inconsistencies in overbite and OVD measurements resulting in subsequent bias. Another limitation in the Van der Zee et al study was that only eight children were sampled at the 30 day follow up when compared to the initial sample size of 56 and the inferences were made only from those patients. This study addressed those concerns by following up the patients more frequently (once a week) to assess changes in the occlusion more accurately. Also, each child received only a single Hall crown. In addition, out of the 51 children who were initially included, the analysis included 44 children who reported for the follow up visits.

The settling of occlusion has also been reported in other studies[9, 15]. In a study on Hall crowns by Innes *et al*,[9] the occlusion showed even contact on both sides of the arch for all the children included in the study at the one year recall appointment. Gallagher *et al* [15] used T-Scan-III system to measure the occlusal contacts following PMC placement and showed results similar to the present study at the end of four weeks.

According to the Dahl concept[16, 17], a large increase in OVD is compensated by intrusion of the restored tooth and its antagonist, re-eruption of other teeth in the arch or a combination of both. Gallager *et al* [15] also suggested that the eruptive potential in younger children along with primary tooth movement resolved the premature contacts in their study. They recommended future research to evaluate the OVD in PMCs placed using the Hall technique. The study by van der Zee *et al* [14] suggested intrusion of the crowned molar and its opposing tooth to be the mechanism of occlusal settlement. They measured the clinical heights of the crowned molar and the antagonist tooth pre operatively and post operatively at 15 days and 30 days to reach this conclusion. However, the procedure could have been better validated with the use of a fixed point and subsequent radiographic analysis. In the present study, we measured the OVD to evaluate the mechanism of settlement of the occlusion. The OVD measurements in this study reverted to baseline by the 3rd week. This implied that the occlusion settled by intrusion of the tooth as any re- eruption of the other teeth in the arch would have caused a permanent change in the post-operative OVD values[16, 17]. But whether, only the restored tooth intruded or whether the antagonist also intruded is a question to be answered through future research. Another limitation in the present study was the use of soft tissue land marks[23] for measuring the OVD. Making use of hard tissue landmarks with the help of radiographs for this purpose would have been a more standardized approach[27, 28].

An interesting finding in this study was that although OVD settled at the third week and did not show a statistically significant difference compared to the pre-operative OVD at the fourth week, the OVD decreased further and this difference was statistically significant. The significance of this four week finding considering that the overbite settled completely only at the end of 4 weeks requires further investigation with an increased follow up period. In addition, the use of a computerized occlusal analysis system like T-Scan- III can give more precise results[13].

In the present study, the mean increase in the overbite and OVD measurements was around 1mm. According to UK National Clinical Guidelines[13] on PMCs for primary molars, occlusal interferences <1 mm are well tolerated with dento-alveolar compensation occurring within a few weeks. Gallagher *et al* [15] also reported occlusal interferences below 1mm in the primary dentition to settle with dento alveolar compensation.

It has been stated in literature that in vulnerable individuals occlusal interferences can predispose to TMD [18, 20, 29] However, it has been noted in the study by Dahl et al[14] that the increase in the OVD resulting from the use of bite planes for orthodontics did not increase the risk of TMD. Gallager *et al* [15] suggested a formal assessment of the TMJ and use of a questionnaire to evaluate the signs and symptoms. In order to evaluate as a secondary aim, if any of the children who received the Hall crowns had signs or symptoms of TMD due to occlusal interference, a questionnaire[26] was provided at the end of one month to the parents. None of the parents reported any signs or symptoms for TMD at the end of one month. Innes at al[9] also reported similar findings. This can also be attributed to the greater adaptability of the masticatory system to occlusal interferences in children.[18]

CONCLUSIONS

Based on the inferences from the current study it can be concluded that:

1. Any changes in occlusion following the placement of a Hall crown settles in a period of four weeks.
2. The OVD settles three weeks post placement of the Hall crown implying that extrusion of teeth do not play a role in settling of the occlusion.
3. Children undergoing this technique do not develop any signs or symptoms of TMD.

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