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Assessment Of The Equilibration Of Occlusion And Periodontal Ligament Changes Following The Placement Of Stainless Steel Crown Using Hall Technique In Children By Intra Oral Digital Radiography-An In Vivo Study

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Abstract

Background: The Hall technique in pediatric dentistry simplifies stainless steel crown placement by avoiding caries removal and tooth preparation. However, the biological basis of occlusal equilibration involving the periodontal ligament (PDL) and alveolar bone remains underexplored.

Aim: To evaluate the mechanism of occlusal settling following stainless steel crown placement using the Hall technique in children.

Design: An in vivo cross-sectional study was conducted on 22 primary molars of 3–7-year-old children. Stainless steel crowns were placed using the Hall technique. Intraoral digital radiographs were taken at baseline, post-restoration, and after one month. PDL space at three root levels and alveolar bone height from the cemento-enamel junction were assessed. Data normality was tested using the Shapiro-Wilks test, and comparisons employed paired t-tests.

Results: Crown placement caused a significant reduction in PDL space ($p<0.001$). Partial recovery at coronal and middle thirds occurred after one month, whereas apical reduction suggested intrusive tooth movement. Alveolar bone changes indicated delayed remodeling. Antagonist teeth also showed significant PDL alterations ($p<0.001$).

Conclusion: The Hall technique is minimally invasive and biologically compatible. Occlusal equilibration occurs through PDL adaptation, bone remodeling, and compensatory changes in opposing teeth.

1.INTRODUCTION

Dental caries is a multifactorial pathological process triggered by microbial changes in the dental biofilm. Disease progression is modulated by an interplay of host factors like salivary composition and flow rate environmental influences such as fluoride exposure and dietary carbohydrate frequency and behavioral determinants particularly oral hygiene maintenance. In its preliminary phase, caries is reversible and can be arrested even with minor cavitation, if biofilm is adequately removed [1]. Initially caries is confined to enamel or superficial dentin, the demineralization process can advance into deeper dental tissues, leading to irreversible structural damage. Critically, dental caries stands as the foremost etiological factor behind the premature loss of primary teeth [2]. Within the primary dentition, caries prevalence demonstrates a strong inclination for specific tooth types, with primary molars representing the most frequently and severely affected teeth[3]. Treating dental caries in primary molars early is pivotal, it prevents early tooth loss, preserves space for permanent teeth, supports proper mastication and speech, and boosts confidence, leading to a better quality of life for children [4] .In conventional pediatric restorative dentistry, the standard approach for managing cavitated carious lesion in deciduous teeth involves complete excavation followed by placement of a direct dental restoration. PMCs have established themselves as the gold-standard restorative intervention for moderate-to-severe carious lesion in primary molars, particularly when multiple surfaces are involved. Crowns fitted through the Hall technique approach require less technical precision and ensures full coverage to the affected tooth [5]

The successful seating of stainless steel crowns is sometimes complicated by the limited cooperation in child patients. Dr. Hall developed a minimalist approach for the application of stainless steel crowns. This technique aims to simplify the procedure and improve acceptance among children by eliminating the requirement for local anesthesia, removing cavities, or tooth reduction [6]. A well- adapted stainless steel crown creates an environment that is hostile to cariogenic bacteria, effectively protecting the tooth from demineralization due to acid attack and enzymatic degradation of organic matrix

An occlusal vertical dimension (OVD) discrepancy is anticipated with the Hall Technique due to lack of occlusal reduction. However, research suggests that occlusal re-equilibration typically happens within 2 to 4 weeks. An increase in occlusal vertical dimension is generally compensated by an amalgamation of intrusion of both the restored tooth and its antagonist, as well as supra eruption of neighbouring teeth within the dental arch.

Traditionally, it has been inferred that stainless steel crowns settle passively over time. Yet, growing research points to the fact that PDL adaptation may play a significant role in this process. Utilizing Hall Technique, investigation assessed occlusal physiological adaptation and dynamic structural modifications within the periodontal ligament space following stainless steel crown application in pediatric dentition. By employing intraoral digital radiography as a validated assessment tool, this research aims to offer valuable insights into the biological response to this minimally invasive restorative approach and its implications for pediatric dentistry

2. METHODS

After getting approval from the ethical clearance this in vivo study, was conducted in the Department pedodontics and preventive dentistry .The study population consisted of children aged three to seven years seeking treatment at the Department of Pediatric and Preventive Dentistry. Participants were selected based on the presence of multi-surface carious lesions involving both enamel and dentin in

Primary molars requiring treatment **(Figure 1).**Only asymptomatic teeth, exhibiting no clinical or radiographic evidence of pulpal or periapical pathology, were included. Children who met the eligibility criteria and demonstrated cooperative behavior were employed in the study after obtaining informed consent from their parents or guardians

VARIABLES

The key variables analyzed in this present study:

- Periodontal ligament (PDL) space
- Alveolar bone height
- Response of antagonist tooth

These variables were evaluated at three time intervals: preoperatively (baseline), immediately after stainless steel crown placement using the hall technique, and one month postoperatively. Periodontal ligament space was calibrated using standardized radiographs taken with the paralleling technique and a digital imaging system. PDL width was measured at three root levels: coronal, middle, and apical thirds. Alveolar bone height was evaluated by measuring the vertical distance from the cemento- enamel junction (CEJ) to the alveolar crest. The response of the antagonist tooth was assessed radiographically for changes in PDL space across the three time points

Hall Technique

Stainless steel crowns were inserted using the hall technique on primary molars exhibiting proximal contact with adjacent teeth **(Figure 2).** In cases, where teeth were not spaced, Orthodontic separators were placed at the contact points for 3 to 5 days to facilitate crown placement. No caries excavation or tooth reduction was performed prior to SSC placement, in accordance with the principles of the Hall Technique. The selection of an appropriate crown size was based on the mesiodistal width of the tooth, vertical crown height, and the overall crown fit. This was determined using a trial-and-error method. The selected crown was luted with glass ionomer cement and seated firmly in place. Since there is no occlusal reduction involved, a propped up occlusion was noted immediately after crown placement **(figure 3).**After one month the occlusal reequilbration was established **(figure 4)**

Clinical and radiographic assessments were conducted at three intervals. Standardized intraoral periapical radiographs (IOPAs) were taken using the paralleling technique with a Rinn XCP holder and a digital phosphor storage plate (PSP) system. The periodontal ligament (PDL) space was measured at the coronal, middle, and apical thirds of the tooth at baseline, immediately after crown placement, and again at 1 month **(Figure 5).**.. All radiographs used consistent exposure settings and imaging protocols. Alveolar bone height was evaluated on standardized intraoral periapical radiographs obtained at baseline, immediately after crown placement, and at the one-month follow-up **(Figure 6).** Occlusal changes involving the opposing teeth were also recorded over the same time intervals to assess any compensatory adjustments following crown placement **(Figure 7).**To improve accuracy, all radiographic images were thoroughly examined under threefold (3×) magnification. This ensured precise visualization of fine anatomical details during PDL space and alveolar bone height evaluation. All measurements were calibrated and noted by a single examiner to maintain consistency.

Figure 1: Class II caries in primary second molar

Figure 2: Preformed metal crown (stainless steel crown) placed on a mandibular second primary molar using the Hall Technique to manage a Class II occluso-proximal lesion.

Figure 3, 4: Lateral views showing initial occlusal elevation and subsequent equilibration at 1 month following Hall Technique crown placement.

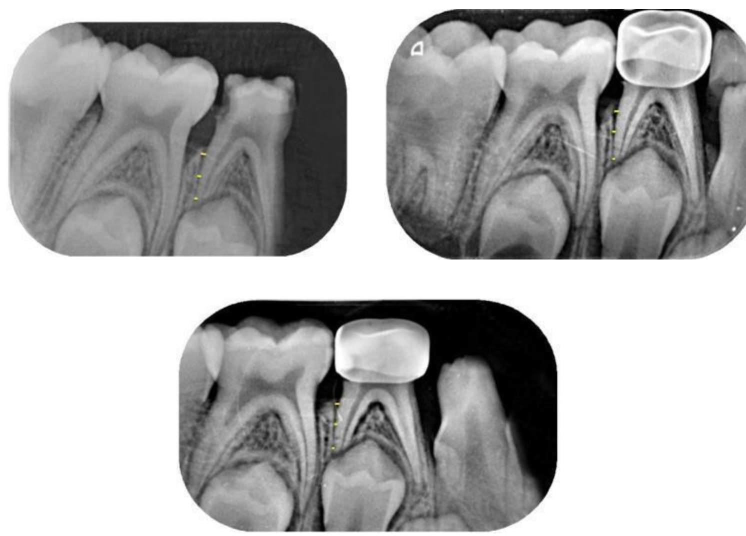

Figure 5: Intraoral periapical radiographs showing radiographic changes of PDL width in primary molars following placement of hall technique crown

Figure 6: IOPA of a primary molar restored with a stainless steel crown using the Hall Technique, showing the reference point for alveolar bone height measurement from the CEJ to the alveolar crest (black arrow).

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Figure 7: Intraoral Radiograph of Antagonist Tooth for Periodontal Assessment

3. RESULTS

Study Population

Twenty-two primary molars from children aged 3 to 7 years (13 boys, 9 girls) were included in the study.

Periodontal Ligament Changes Immediately After Crown Placement

Paired t-tests revealed a significant reduction in PDL space at all root levels immediately post-placement: coronal (mean reduction 0.46 mm, $p < 0.001$), middle (0.35 mm, $p = 0.003$), apical (0.45 mm, $p < 0.001$), and overall PDL (0.4 mm, $p < 0.001$).

One-Month Follow-Up PDL Adaptation

At one month, the coronal and middle third PDL spaces showed partial recovery without statistically significant differences from baseline ($p = 0.376$ and $p = 0.097$, respectively), whereas the apical third exhibited a significant further reduction (0.63 mm, $p < 0.001$), indicating intrusive movement.

PDL Compensation over Time

The mean PDL thickness decreased from 1.52 mm preoperatively to 1.08 mm immediately after crown placement and partially recovered to 1.20 mm at one month ($p < 0.001$).

Alveolar Bone Remodeling

Alveolar bone height remained unchanged immediately after crown placement but demonstrated a significant decrease by one month (mean reduction 0.19 mm, $p < 0.001$), suggestive of delayed bone remodeling.

Antagonist Teeth Adaptation

PDL thickness of antagonist teeth significantly reduced at one month (mean difference 0.0248 mm, $p < 0.001$), indicating compensatory changes.

4. DISCUSSION

Contemporary strategies such as non-restorative caries treatment (NRCT) and the hall technique represent a significant shift, emphasizing towards conservation of tooth structure and biological sealing over extensive cavity preparation [7]. These biological interventions, which stop caries progression through biofilm modification rather than tissue excision, show improved preservation of tooth structure.

reduced treatment morbidity, and enhanced longevity of tooth preservation after restorative procedure [8-9]. The clinical efficacy of Hall technique stems from a dual mechanism, complete caries sealing that creates an anaerobic environment unfavourable for cariogenic bacteria, and physical separation of microbial colonies from fermentable carbohydrate substrates. This biologically conservative approach achieves caries arrest while preserving maximal tooth structure and minimizing iatrogenic damage [10-11]

Traditionally, stainless steel crowns placed using the Hall Technique are believed to undergo passive occlusal settling through the adaptive capacity of the masticatory system. However, the exact physiological mechanisms particularly the roles of periodontal ligament compression, alveolar bone remodeling, and vertical intrusion of the antagonist tooth remain unexplored. Placement without occlusal reduction increases the vertical dimension by about 0.525 mm due to crown and cement thickness. This study intends to evaluate the biological mechanism of the periodontal ligament and alveolar bone to these dimensional changes in pediatric patients

In this study, twenty-two children aged 3 to 7 years with multi-surface carious lesions in primary molars were included, out of which 13 were boys and 9 were girls **(Graph 1).** Most of the treated teeth were primary first molars, which is clinically relevant considering their anatomical characteristics **(Graph 2**). This is in hand with the findings of **Cheong et al. (2019)**[12]**,** who demonstrated through micro-computed tomography that first primary molars possess thinner surrounding tooth structure than second primary molar**s,** particularly on the mesial and distal walls, making them more vulnerable to loss of structural integrity during restorative interventions. PDL space and alveolar bone height were evaluated using intraoral digital radiography at baseline, immediately upon crown placement, and one month post-placement.

The descriptive statistics of periodontal measurements taken immediately after crown placement, recording the immediate impact of the procedure on the periodontal ligament shows a marked reduction in PDL width across all regions These active changes are statistically supported in (**Table 1),** which validates significant reduction in all three regions**.** This pattern emphasizes the periodontal ligament's role as a mechanoresponsive tissue, capable of rapid structural adaptation to altered occlusal forces. As **Wen et al. (2025)**[13] describe, the PDL is a regionally heterogeneous structure that not only anchors the tooth but also effectively transmits and dissipates occlusal forces, a role essential for maintaining dental and periodontal stability under dynamic loading conditions. Moreover, mechanical stress concentrated in the buccal cervical region and collar area can result in localized reductions in PDL thickness, as substantiated by **Zhong et al(2021)** [14] who demonstrated microstructural heterogeneity and compression-specific alterations in the collagen network of the loaded PDL.

At the one-month follow-up, the PDL space measurements demonstrated a trend toward recovery, particularly in the coronal and middle thirds; however, these variations were not statistically significant **(Table 2).** On the other hand, the apical region exhibited a significant decrease in PDL width suggesting a continuing biological response likely associated with intrusive movement of the crowned tooth as part of the occlusal equilibration process. This observation aligns with the findings of **van der Zee and van Amerongen (2010)** [15]who proposed the reduction in overbite following Hall crown placement was ascribed to the intrusive displacement of both the crowned molar and its antagonist. Similarly, **Evans et al (2015)**[16] reported a marked reduction in occlusal vertical dimension from 1.1 mm immediately post-treatment to 0.3 mm after two weeks, based on digital modeling and clinical photography .Additionally, these findings are in accordance with those of **Nair and Chikkanarasaiah et al. (2020)**[17] and **Rose Maria and Ashwin P. Rao et al. (2020)** [18] both of whom concluded that occlusal re-equilibration is typically attained by one month following SSC placement using the Hall Technique.

The mean PDL compensation over time indicates a declining trend in values from 1.52 mm pre- operatively to 1.08 mm immediately after placement and partially recovering to 1.20 mm after one month, as shown in **(Table 3)** The total mean difference in PDL observed from pre- operative to one-month post-operative was
0.31 mm, obtained by subtracting the post- operative value from the pre-operative measurement, and this falls within the range of the natural PDL space width typically reported to be between 0.15mm and 0.38 mm as described by **Nanci and Bosshardt (2006)**[19]

·This suggests that the counterbalancing remodeling observed may reflect a physiological adaptation within the normal functional limits of the periodontium. Alveolar bone height measurements, established insignificant change immediately post-operatively likely because of the acute post- intervention phase, during which bone remodeling processes may not yet have been initiated or become radiographically evident. A significant reduction to was noted at the one-month follow-up (**Table 4)** indicating that osseous remodeling becomes more gradually, This pattern is in consistent with findings from **Rizk et al. (2023)** [20] , who reported notable alveolar bone changes within five weeks of orthodontic force application

While **(Table 5)** confirms a significant decrease in alveolar bone height between baseline and one month (mean with the mean alveolar bone compensation of 0.19 mm obtained by subtracting the one-month post-operative value from the reference measurement. This shows that osseous remodeling occurs as a secondary response in the process of occlusal equilibration .Bone remodeling is a intricate process involving osteoblasts and osteoclasts, and it is influenced by mechanical stimuli [21] .The observed reduction in alveolar bone height at the one-month follow-up could be attributed to the bone's response to the altered occlusal forces resulting from the increased OVD (occlusal vertical dimension) after crown placement. This remodeling is likely a gradual process, which explains the late onset of changes in bone height relative to the immediate response of the PDL.

The antagonist PDL and alveolar bone also showed the impact of SSC placement on the antagonist tooth. With an average PDL reduction of 0.0248 ± 0.0014 mm ($p < 0.001$), this reduction was statistically significant in (**Table 6**), indicating significant region-wise differences. According to these results, the antagonist teeth may provide occlusal adaptation through minor periodontal changes that preserve the occlusal balance. This is corroborated by the data in (**Table 7**), which showed a corresponding mean change in antagonist alveolar bone height, also measured at 0.0248 mm. This supports the idea that biological adaptation affects both the crowned tooth and its opposing counterpart.

This is supported by the **Dahl concept** [22]which shows that re-eruption of other teeth, intrusion of the restored tooth and its antagonist, or a combination of these factors can compensate for increased OVD. Results from **Herkar et al. (2021)** [23] who used finite element stress analysis, further support this idea. They found that OVD increase by about 0.62 mm right after SSC placement but nearly returned to baseline levels two weeks later.

In relation to study conducted by **Gallagher etal** [24] pointed out that minimal occlusal discrepancies (<1 mm) in children elicit effective compensatory mechanisms through alveolar bone remodeling and tooth movement, with the immature masticatory system demonstrating significantly quicker adaptive responses compared to adults for occlusal re-equilibration. Our study confirms that the resulting increase in OVD is compensated by initial PDL compression, alveolar bone adaptation, and minor antagonist tooth movement. Strengths of this study include the utilization of digital radiography with the paralleling technique and 3x image magnification, which augmented measurement precision of the PDL space. Future research with advanced imaging like CBCT could provide a more extensive assessment of hard and soft tissue changes.

This study provides valuable insights but has limitations. The small sample size may limit generalizability, and palatal root superimposition could reduce radiographic accuracy of maxillary molars with IOPA. Future research with larger samples and 3D imaging could improve measurement precision. Examining factors like gender-based bite force and its effect on occlusal equilibration timing would offer further understanding.

This study confirms that the alveolar bone and periodontal ligament play a dynamic role in promoting occlusal equilibration after the Hall Technique. A combined biological response to the changed occlusal vertical dimension is reflected in the observed immediate compression and gradual adaptation of the PDL as well as delayed but notable changes in alveolar bone height. Furthermore, the idea of a dentoalveolar compensatory mechanism is further supported by the slight but notable alterations in the antagonist teeth. These results support the Hall Technique as a minimally invasive, biologically sound treatment method while also challenging the conventional idea of passive crown "settling." The Hall Technique is still a game-changer in pediatric restorative dentistry because of its widespread acceptance, clinical effectiveness, and ease of adaptation. Future research using cutting-edge imaging. To better understand the extended tissue response and occlusal stability, future research using sophisticated imaging and longer monitoring is encouraged

Why this paper is important to pediatric dentistry:

- **Supports minimally invasive, child-friendly treatment**: The Hall Technique eliminates the need for local anesthesia, caries removal, or tooth preparation, making it easier to manage uncooperative young patients while still providing effective tooth protection.
- **Highlights biological mechanisms of occlusal adaptation**: By showing how the **periodontal ligament (PDL)** and alveolar bone adapt following crown placement, the study explains the natural equilibration process—important for ensuring safety and stability of increasing occlusal vertical dimension in growing children.
- **Provides evidence for clinical predictability and acceptance**: The study confirms that stainless steel crowns placed with the Hall Technique equilibrate within about one month through dentoalveolar adaptation, reinforcing its role as a reliable, biologically sound, and widely applicable restorative method in pediatric practice.

TABLE 1: CHANGES IN PERIODONTAL LIGAMENT MEASUREMENTS BEFORE AND IMMEDIATELY AFTER CROWN PLACEMENT

	Pre op	Immediately after crown placement	Mean diff	P value *
Coronal third (mm)	1.74±0.52	1.28±0.5	0.46±0.24	<0.001
Middle third	1.43±0.57	1.07±0.49	0.35±0.47	0.003
Apical third	1.37±0.5	0.92±0.38	0.45±0.38	<0.001
PDL	1.49±0.47	1.08±0.39	0.4±0.16	<0.001

Values expressed as mean ± standard deviation (SD).

PDL = Periodontal ligament.

*P-values calculated using paired t-test.

TABLE 2: CHANGES IN PERIODONTAL LIGAMENT MEASUREMENTS BEFORE AND ONE MONTH AFTER CROWN PLACEMENT

	Pre op	Post 1 month followup	Mean diff	P value *
Coronal third (mm)	1.74±0.52	1.67±0.54	0.074±0.36	0.376
Middle third	1.43±0.57	1.37±0.5	0.18±0.47	0.097
Apical third	1.37±0.50	0.73±0.48	0.63±0.49	<0.001
PDL	1.49±0.48	1.20±0.42	0.29±0.22	<0.001

Values expressed as mean ± SD.

PDL = Periodontal ligament.

*P-values calculated using paired t-test.

TABLE 3 : MEAN PDL COMPENSATION BEFORE AND AFTER CROWN PLACEMENTS

	N	Minimum	Maximum	Mean	Std. Deviation
Pre-op	22	.76	2.43	1.5205	.47768
Immediate	22	.47	1.77	1.0825	.39562
Post-op one month	22	.47	1.90	1.2025	.42348
Difference (Pre-op - Post-op)	22	-.14	.79	.3180	.22225

TABLE 4 : MEAN ALVEOLAR BONE MEASUREMENTS COMPENSATION BEFORE AND ONE AFTER CROWN PLACEMENTS

	N	Minimum	Maximum	Mean	Std. Deviation
Pre-op	22	3.40	4.50	3.9600	.33309
Immediate	22	3.40	4.50	3.9585	.33106
Post-op one month	22	3.20	4.40	3.7700	.33733
Difference (Pre-op - Post-op)	22	.00	.30	.1950	.09987

Values expressed as mean ± SD.

Measurements reported in millimetres

TABLE 5: CHANGES MEAN ALVEOLAR BONE MEASUREMENTS COMPENSATION BEFORE AND ONE MONTH AFTER CROWN PLACEMENTS

	Pre op	Post 1-month follow-up	Mean diff	P value *
Alveolar bone compensation	3.96±0.33	3.77±0.34	0.19±0.09	<0.001

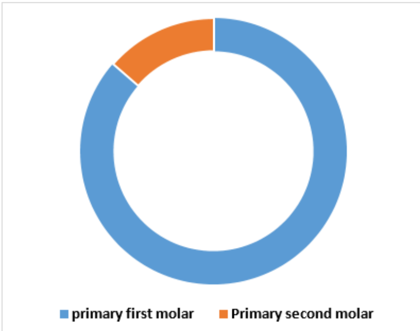
TABLE 6: PERIODONTAL LIGAMENT MEASUREMENTS OF ANTAGONIST TEETH ONE MONTH AFTER CROWN PLACEMENT

	N	Minimum	Maximum	Mean	Std. Deviation
Coronal	22	1.34	1.60	1.4568	.06999
Middle	22	1.35	1.61	1.4645	.06933
Apical	22	1.35	1.60	1.4641	.07076
Mean	22	1.35	1.60	1.4616	.07021

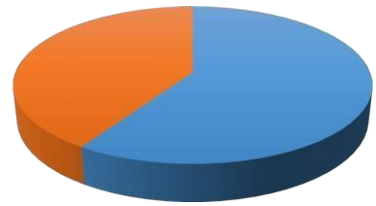
TABLE 7: MEAN ANATOGONIST TEETH COMPENSATION

	N	Minimum	Maximum	Mean	Std. Deviation
Difference	22	.022	.027	.02482	.001402

Graph 2 : Distribution Of Treated Teeth In The Study



Graph 1: Gender Distribution



Author Contributions:

Dr Alisha T Susan conceptualized the study, designed the research methodology, and carried out data collection and analysis. Dr Amith Adyanthaya and Dr Karthik Nair, Dr.Anju R V conceived the core idea for the research. Dr Aiswarya M V, Dr Hanna K Hafiz, Jadeera N A ,Dr Krishna N S contributed to data analysis and provided assistance with the literature review. All authors approved the final manuscript and are accountable for all aspects of the work.

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Patient Consent Statement: Written informed consent was obtained from parents/guardians before inclusion, using the approved information and consent forms.

Data Availability Statement: Data supporting the findings of this study are available from the corresponding author upon reasonable request.

Word Count: 3220 (excluding tables, figures, and references)

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