RANDOMIZED CONTROL TRIAL

Success and Behavior During Atraumatic Restorative Treatment, the Hall Technique, and the Stainless Steel Crown Technique for Primary Molar Teeth

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Abstract: ***Purposes:*** *The purposes of this prospective trial were to: (1) compare the clinical and radiographic outcomes of three restorative methods—modified atraumatic restorative treatment (mART), the Hall technique (HT), and stainless steel crown (SSC)—in primary molars with multisurface carious lesions; and (2) assess child behavior throughout these treatments.* ***Methods:*** *In this randomized controlled trial (RCT), 123 primary molars in four- to nine-year-old children were randomly divided into treatment groups (HT, mART, and SSC). Variables, including signs of failure, treatment time, child's discomfort, child's behavior, and canine overbite relationship in HT, were recorded immediately after the treatment and at six- and 12-month recalls.* ***Results:*** *Failures occurred most significantly for mART at all recalls (P=0.001). The treatment time was significantly higher in SSC. There was no significant difference in the child-assessment of discomfort (P=0.814). The child's behavior, as evaluated by the dentist, however, was significantly better for the SSC group. Alterations to the canine overbite relationship of HT decreased significantly during recalls (P<0.001).* ***Conclusions:*** *The high success and shorter treatment time of the Hall technique support its consideration as an alternative to the conventional technique for the treatment of carious primary teeth with multisurface lesions. The results for modified atraumatic restorative treatment were not as satisfying.* *(Pediatr Dent 2020;42(3):187-92) Received May 17, 2019 | Last Revision February 17, 2020 | Accepted February 21, 2020*

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Despite recent advancements in dentistry, dental caries has remained a global health problem, especially in developing countries.[1] Progression in dental materials has changed the concept of operative methods (so-called 'drill and fill') toward more conservative treatments, such as remineralization of early caries or application of operative techniques that maintain sounder dental tissue.[2]

Recent studies have shown that complete excavation of carious lesions is inefficacious and more time-consuming, costly, and painful than conservative techniques.[3] Successful application of techniques that are more conservative, less time-consuming, and less likely to generate pain is important in pediatric dentistry to generate patient comfort and cooperation. Conservative techniques can also eliminate the need for local anesthesia.[3] Recent evidence has shown the clinical success of 'no caries removal' techniques[4,5,6] that intentionally leave carious dentin intact. As long as the seal is adequate, bacteria do not continue the disease process, resulting in clinical success.[3]

The Hall technique (**HT**) and atraumatic restorative treatment (**ART**) are two partial/no caries removal methods. HT is named after Norna Hall, who developed a simplified technique of treating the carious lesions of primary molars with no tooth preparation and sealing the lesion using preformed metal crowns.[7] While several RCTs note the HT to be equally or more successful than multisurface restorations, none compare the technique to stainless steel crowns (**SSC**).[8-10] One retrospective study suggests that the HT compares favorably to SSC.[11]

ART was initially introduced as a method of delivering dental care to deprived communities. It includes removal of soft carious tissue using only hand instruments and restoring with an adhesive dental material.[6] ART was modified (**mART**) by using high-speed rotating diamond bur on enamel. The modified technique adapts to conventional dental service equipment, saves time and energy, provides better visualization of the lesion, causes less manual fatigue, and decreases patient's discomfort.[7]

The purposes of this prospective trial were to: (1) compare the clinical and radiographic outcomes of three restorative methods—modified atraumatic restorative treatment, the Hall technique, and stainless steel crowns—in primary molars with multisurface carious lesions; and (2) assess child behavior throughout these treatments.

Methods

This randomized controlled parallel designed trial was conducted between September 2015 and June 2017 in the Pediatric Dentistry Department, Mashhad University of Medical Sciences, Mashhad, Iran. The study design was approved by the Ethics Committee of Mashhad University of Medical Sciences, Mashhad, Iran. A postgraduate student from the Department of Pediatric Dentistry delivered the treatments. Four- to nine-year-olds who had at least one primary molar with multisurface caries affecting at least one interproximal surface were recruited. Other inclusion criteria were good general health, past cooperative dental history with local anesthesia, and high risk of caries incidence as defined by the American Academy of Pediatric Dentistry.[12] Written and verbal informed consent was obtained from parents or guardians of the children.

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After clinical and periapical radiographic evaluations, some patients were excluded for the following reasons: clinical evidence of pulpal involvement of the respected tooth (nocturnal or spontaneous pain, dental abscess, fistula, and mobility); urgent dental needs; radiographic evidence of pulpal involvement or periapical lesion; and doubtful presence of an intact dentin layer between the lesion and pulp.

The study power was set at 80 percent (α equals 0.05). The authors estimated 20 percent attrition in samples (loss to follow-up) after 12 months. Hence, this study's sample size was estimated to be a total of 120 teeth (approximately 40 teeth in each group). Patient recruitment was completed within four months. Each participant had only one tooth treated for this study; if more than one tooth fulfilled selection criteria, the experimental tooth (sample) was randomly selected and other teeth were treated according to the routine treatment plan. Samples were randomly assigned to one of three experimental groups: (1) HT; (2) mART; and (3) SSC. One of the department staffers generated computer block randomization numbers. A dental nurse assigned participants for treatment. The practitioner was blind to the allocation until the patient was assigned to the trial. All patients were treated with basic behavior guidance techniques, such as tell-show-do.

HT group. Canine overbite was calculated before the preparation by measuring the distance between incisal points of the maxillary canine on the same side of the mouth to the gingival zenith of the mandibular canine using a Boley Gauge (Buffalo Dental Manufacturing Co., Brooklyn, N.Y., USA). If checking the same side was not possible (e.g., loss of canine) the distance between canines on the other side was measured. The technique outlined in the most recent user's manual was utilized.[13] After assessing tooth shape and occlusion, the SSC (3M ESPE, St. Paul, Minn., USA) was sized without fully seating it. These prefabricated SSCs are pre-trimmed to the optimum length, belled, and pre-crimped at the cervical margin. The SSC was loaded with glass ionomer luting cement (Fuji Triage, GC Corp., Tokyo, Japan) and partially fitted on the tooth using a finger. The patient bit on a cotton roll, and the SSC was fully seated. Excess cement was removed. Post-treatment overbite was recorded, as described formerly.

mART group. To avoid any change in occlusion, pretreatment and post-treatment overbite were measured, as described for group one. As the patients were treated in a clinic setting, it was deemed most acceptable to use the mART method rather than ART. Marginal enamel adjacent to the carious lesion was removed with a high-speed bur (Teezkavan Co., Tehran, Iran). Further modification of the technique was made via low-speed bur (Teezkavan Co., Tehran, Iran) for bulk removal of the soft dentin. Soft carious dentin was removed using tactile criteria. Leathery dentin was left to avoid pulp exposure and elicitation of painful stimulation.[3]

The tooth was isolated with cotton rolls, and a matrix and wooden wedge were used. As a new modification, the cavity was filled with high-viscosity resin-modified glass ionomer light-cured universal restorative cement (GC Gold Label, GC Corp., Tokyo, Japan) using the layers techniques (light curing in two-mm increments each time). Occlusion was adjusted, as necessary, with a high-speed finishing bur (Teezkavan Co., Tehran, Iran).

SSC group. Canine overbite was measured before the preparation, as described for the HT group. Local anesthesia with two percent lidocaine (1:100,000 epinephrine) was applied. Interproximal surfaces were reduced using a no. 69 L bur (Teezkavan Co., Tehran, Iran) with a high-speed handpiece. The bur was used to reduce the occlusal portion after obtaining one-mm clearance with the opposing tooth. Sharp angles were removed. The remaining caries was excavated by low-speed round bur. If removal of carious tissue resulted in pulp exposure, the tooth was excluded from the study and the patient received conventional treatment.

An appropriately sized, prefabricated precrimped SSC (3M ESPE, St. Paul, Minn., USA) was selected. Posttreatment canine over-bite was measured to avoid any change of occlusion. If necessary, the length of the crown was adjusted and trimmed with crown scissors, the edges were polished with an abrasive stone, and contouring and crimping were performed. The SSC was cemented using glass ionomer luting cement (Fuji Triage).

At the appointed treatment, the following were recorded for all groups:

- The time of treatment (minutes) was measured by a digital chronometer (HS45-001, Q & Q, Tokyo, Japan).
- Immediately after the treatment, any pain and discomfort experienced by the child were recorded using the Faces Pain Scale-Revised (**FPS-R**). The patient was instructed to circle the face that corresponded to the pain level and experienced discomfort during the treatment. Six FPS-R faces are scored as 0–2–4–6–8–10.[14]
- At the end of the treatment session, the dentist classified the child's behavior during the treatment according to the Frankl scale. The Frankl scale describes four types of behavior during dental treatment: (1) definitely negative equals one; (2) negative equals two; (3) positive equals three; and (4) definitely positive equals four.[15] One practitioner evaluated the overall behavior of all patients to ensure the consistency of the scores.

Table 1. DISTRIBUTION OF TOOTH TYPE IN TREATMENT GROUPS

Primary tooth type				Treatment groups *			Total	*P*-value †
				HT	mART	SSC		
Maxillary	Right	First molar	N (%)	5 (38.5)	5 (38.5)	3 (23.1)	**13 (100.0)**	0.104
		Second molar	N (%)	7 (43.8)	6 (37.4)	3 (18.8)	**16 (100.0)**	
	Left	First molar	N (%)	1 (20.0)	2 (40.0)	2 (40.0)	**5 (100.0)**	0.622
		Second molar	N (%)	5 (45.4)	3 (27.3)	3 (27.3)	**11 (100.0)**	
Mandibular	Left	First molar	N (%)	6 (40)	4 (26.7)	5 (33.3)	**15 (100.0)**	0.778
		Second molar	N (%)	7 (29.2)	8 (33.3)	9 (37.5)	**24 (100.0)**	
	Right	First molar	N (%)	6 (28.6)	5 (23.8)	10 (47.6)	**21 (100.0)**	0.166
		Second molar	N (%)	5 (27.8)	9 (50.0)	4 (22.2)	**18 (100.0)**	
Total			**N (%)**	**42 (34.1)**	**42 (34.1)**	**39 (31.7)**	**123 (100.0)**	

* N=Number † Chi-square test.
HT=Hall technique; mART=modified atraumatic restorative treatment; SSC=Stainless steel crown.

- To determine parental satisfaction with treatment, parents were asked to respond to the question, "What is the level of your satisfaction with the treatment your child received?" using a four-point Likert scale (very low equals one; low equals two; medium equals three; and high equals four).

The patients were re-examined six and 12 months after the treatment. At recalls, clinical and radiographic evaluations were recorded. Any sign of either clinical or radiographic major failure was considered a failure. Clinical signs of major failure were sensitivity to percussion, spontaneous or nocturnal pain, and loss of restoration or SSC. Clinical signs of minor failure were recurrent caries or minor fracture of restoration (in the mART group). Radiographic signs of major failure were obvious furcation or periapical radiolucency and internal or external radiolucency. Radiographic signs of minor failure were slight internal resorption and slight widening of the periodontal ligament.

Note that canine overbite was only measured for HT because posttreatment occlusion was necessarily unchanged in other groups.

In case of any major failure, the patient received conventional treatment at the pediatric dentistry department. If major treatment failure was detected at the six-month recall, the patient was referred for further treatment and the case was recorded as a major failure at the 12-month recall, as well.

Baseline and recall data were analyzed using Fisher's exact, Kruskal-Wallis, Mann-Whitney, and Chi-square tests using SPSS 20 software (IBM Corp., Armonk, N.Y., USA). The level of significance was set at $P \leq 0.05$.

Results

A total of 123 four- to nine-year-olds (77 girls and 46 boys) were recruited (42 in the HT group, 42 in the mART group, and 39 in the SSC group). The study included one primary molar for each child participating. The type of teeth (mandibular or maxillary, first or second) was not significantly different between groups ($P>0.05$; Table 1).

At the six-month recall, 42 patients (100 percent) in the HT group, 37 patients (88 percent) in the mART group, and 36 patients (92 percent) in the SSC group were available for evaluation. The reasons for dropout included no response on call, lack of parents' cooperation, and family migration. Also, the occurrence of major and minor clinical and/or radiographic failures was significantly higher in the mART group than the HT group (chi-square test, $P=0.011$ and $P=0.009$ for major and minor failures, respectively) and the SSC group (chi-square test, $P=0.005$ and $P=0.010$ for major and minor failures, respectively). No significant difference was detected between the HT and SSC groups in major and minor treatment failures ($P=1.00$; Figure).

After 12 months, 34 patients (80 percent) in the HT group, 32 patients (76 percent) in the mART group, and 30 patients (76 percent) in the SSC group were available for evaluation. Major and minor clinical and/or radiographic failures were significantly higher in the mART group than the HT group (chi-square test, $P=0.001$ and $P=0.009$ for major and minor failures, respectively) and the SSC group (chi-square test, $P<0.001$ and $P<0.001$ for major and minor failures, respectively). No significant difference between the HT and SSC groups was considered in major and minor treatment failures at the 12-month recall ($P=1.00$; Figure).

Fisher's exact test also resulted in no statistically significant difference in the occurrence of failure regarding the tooth type (maxillary or mandibular, first or second molars) with either of the three techniques during the first or second recalls (Table 2; $P>0.05$).

The mean treatment time for the HT, mART, and SSC groups were 8.4±4.9, 11.1±5.2, and 17.3±5.1 minutes, respectively. The mean treatment time for the SSC group was significantly more than for the mART group ($P<0.001$) and the HT group ($P<0.001$). There was no significant difference between the HT and mART groups ($P=0.053$).

Self-reported pain and discomfort were recorded for 39 patients (92 percent) in the HT group, 40 patients (95 percent) in the mART group, and 36 patients (92 percent) in the SSC group. Several patients did not report their experience using the FPS-R due to fatigue, lack of cooperation, or lack of interest. Patients in the HT group showed slightly lower-than-average FPS-R scores, and patients in the SSC group showed slightly higher-than-average FPS-R scores. The mean difference was meaningful but not statistically significant ($P=0.814$). According to Frankl scores, patients' behavior and cooperation were significantly better in the SSC group than in the HT and mART groups ($P=0.002$ and 0.010, respectively); however, the difference between the HT and mART groups was not significant ($P=0.602$; Table 3). Six patients with the worst behavior (Frankl scale) reported the lowest level of self-reported pain and discomfort.

Changes in the canine relationship were determined by subtracting the follow-up canine overbite from the baseline (pretreatment). The mean posttreatment overbite (immediately after the treatment) decreased by 2.4 mm compared to the baseline (pretreatment). After six and 12 months, the mean change decreased to 1.40 mm and 0.31 mm, respectively, which demonstrates a relapse of occlusal changes (Table 4).

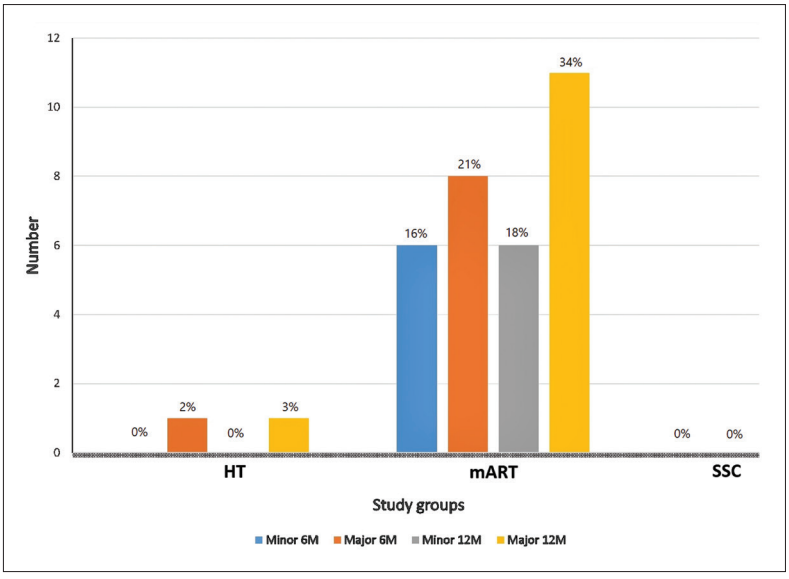

Figure. Number of major and minor failures in study groups after six months (6M) and 12 months (12M).*

* HT=Hall technique; mART=modified atraumatic restorative treatment; SSC=conventional stainless steel crown.

Parents reported a high degree of satisfaction posttreatment, which was not significantly different among all three groups. At both recalls, all parents were satisfied with HT and SSC treatments. But there was a significant dissatisfaction for mART at both recalls (P=0.001; Table 5). There were some missing data because the parent or guardian was absent or sick.

Discussion

SSC is the most reliable treatment for multisurface caries of primary molars in high-caries-risk children outperforming amalgam or resin restorations.[16-20] Consequently, SSC was used as a standard treatment in the control group. In accordance with the results of this study, the mART group showed the greatest rate of both major and minor failures in both recalls. This is consistent with the results of two meta-analysis studies, which indicated that, despite the high survival rate of single-surface ART restorations of primary teeth, the survival rate of multisurface restorations was low.[21,22]

The current study resulted in no significant difference between the SSC and HT groups at both recall visits for major and minor failures. These findings are consistent with the results of several studies showing clinical success of the HT versus conventional restorations.[11,23-25]

This study's results found that the treatment time in the SSC group was significantly higher than for the mART and HT groups. This can be explained by the increased number of clinical steps

Table 2. TOOTH TYPE-RELATED DISTRIBUTION OF TREATMENT FAILURES

Dental arch	Type of failure/ recall time	Occurrence of failure	Number of each tooth type			P-value*
			First molar	Second molar	Total	
Maxillary	Major/ 6-months-recall	No	18	16	**34**	**0.486**
		Yes	0	1	**1**	
		Total	**18**	**17**	**35**	
	Major/ 12-months-recall	No	18	16	**34**	**0.486**
		Yes	0	1	**1**	
		Total	**18**	**17**	**35**	
	Minor/ 6-months-recall	No	18	17	**35**	–
		Yes	0	0	**0**	
		Total	**18**	**17**	**35**	
	Minor/ 12-months-recall	No	18	17	**35**	–
		Yes	0	0	**0**	
		Total	**18**	**17**	**35**	
Mandibular	Major/ 6-months-recall	No	28	25	**53**	**0.255**
		Yes	2	6	**8**	
		Total	**30**	**31**	**61**	
	Major/ 12-months-recall	No	26	24	**50**	**0.508**
		Yes	4	7	**11**	
		Total	**30**	**31**	**61**	
	Minor/ 6-months-recall	No	27	28	**55**	**1.00**
		Yes	3	3	**6**	
		Total	**30**	**31**	**61**	
	Minor/ 12-months-recall	No	27	28	**55**	**1.00**
		Yes	3	3	**6**	
		Total	**30**	**31**	**61**	
Total	Major/ 6-months-recall	No	46	41	**87**	**0.159**
		Yes	2	7	**9**	
		Total	**48**	**48**	**96**	
	Major/ 12-months-recall	No	44	40	**84**	**0.217**
		Yes	4	8	**12**	
		Total	**48**	**48**	**96**	
	Minor/ 6-months-recall	No	45	45	**90**	**1.00**
		Yes	3	3	**6**	
		Total	**48**	**48**	**96**	
	Minor/ 12-months-recall	No	45	45	**90**	**1.00**
		Yes	3	3	**6**	
		Total	**48**	**48**	**96**	

* Fisher's exact test.

Table 3. FACES PAIN SCALE-REVISED (FPS-R)* AND FRANKL† SCORES

Treatment groups‡	N	Mean±(SD)§	P-value‖
FPS-R			
HT	39	2.15±3.47	0.814
mART	40	2.65±3.77	
SSC	36	2.94±4.24	
Frankl scores			
HT	42	2.20±1.20	0.001
mART	42	2.98±1.11	
SSC	39	3.12±1.17	

* Child's self-reported pain and discomfort; FPS-R range=1-10.
† Dentist's evaluation of the patient's behavior; Frankl score range=1-4.
‡ HT=Hall technique; mART=modified atraumatic restorative treatment; SSC=stainless steel crown.
§ Standard deviation.
‖ Kruskal-Wallis test.

Table 4. CHANGE IN THE CANINE OVERBITE RELATIONSHIP*

Time of evaluation	N	Mean±(SD)†	P-value‡
Posttreatment	42	2.4±2.00	<0.001
6-month recall	42	1.40±1.08	
12-month recall	42	0.31±0.51	

* Change in the canine overbite relationship is calculated from the baseline (pretreatment) for the Hall technique (mm) for each evaluation time.
† SD=Standard deviation.
‡ Kruskal-Wallis test.

Table 5. PARENTS' SATISFACTION WITH TREATMENT

Time of evaluation	Treatment groups*	N	Mean±(SD)†	*P*-value ‡
Posttreatment	Hall	38	3.76±0.634	0.156
	mART	42	3.79±0.565	
	SSC	38	3.45±0.978	
6-month-recall	Hall	38	4±0	**0.001**
	mART	37	3.57±0.867	
	SSC	34	4±0	
12-month-recall	Hall	34	4±0	**<0.001**
	mART	31	3.19±1.195	
	SSC	31	4±0	

* HT=Hall technique; mART=modified atraumatic restorative treatment; SSC=stainless steel crown.

† Parents' satisfaction: very low=1; low=2; medium=3; high=4; SD=Standard deviation.

‡ Kruskal-Wallis test.

for conventional treatment, including the application of local anesthesia, reduction of tooth surfaces, complete removal of caries, and occlusal adjustment. This is consistent with the results of a study by Innes et al., which showed less treatment time for HT compared to conventional restorations.[8]

Because of similar success with HT versus SSC and a higher success rate than mART, HT can be considered an alternative to both mART and SSC for the treatment of carious primary teeth with multisurface lesions, especially when shorter duration of treatment is essential—such as with treatment of uncooperative children or when access to dental care is limited.

Patients' behavior (Frankl scale) was significantly better in the SSC group than the mART and HT groups, but there was no significant difference between the HT and mART groups. This finding is in contrast with the results of a study by Innes et al., who compared HT with conventional restorations and revealed that HT caused less pain and discomfort.[8] The observed improved behavior using HT might be attributed to added SSC procedures, which are believed to be the major sources of pain and discomfort (injection of local anesthesia and caries excavation).[26] However, the current study found that the best behavior was seen in the SSC group.

The finding of better behavior scores for the SSC group in this study may be related to the fact that the child's behavior is evaluated during the whole process of the treatment. Although children might show levels of discomfort at the time of injection, they generally did not experience pain or discomfort during the remaining treatment session, resulting in better behavior than seen with the other two groups (mART and HT) that did not receive anesthesia. Better behavior after receiving local anesthesia can change the dentist's total perception of the child's behavior. Another possible reason that children in the SSC group exhibited better behavior may be past positive dental experience—as all children had experienced previous dental care, including local anesthesia.

Regarding the results of this study, the difference between the average intensity of pain and discomfort reported by children was not statistically significant between groups. Bell et al., reported that most patients and parents found HT and SSC to be acceptable and most children easily accepted both treatments.[27] However, there may have been be some recall bias because of the retrospective nature of their study.

The difference between a dentist's evaluation of the child's behavior and a child's perception of discomfort might be related to the reality that the dentist could not ignore the treatment type (blinding was not possible). Additionally, children tend to select the two ends of the FPS-R scale (the happiest and the saddest faces). This could have resulted in bias, especially when several children who were identified by the dentist as showing definitely negative behavior chose the happiest face.

In this study, all parents reported a high degree of satisfaction immediately after the treatment. At both recalls, parents remained highly satisfied with the treatment in the HT and SSC groups. This is consistent with a study by Page et al. that also showed a high degree of acceptance for HT among parents and children.[28] However, there was a significant dissatisfaction in the mART group at both recalls. This is not surprising due to the higher incidence of minor and major failures in this group.

Based on HT's high success rate, it is suggested as a method for delivering dental care to children from deprived communities instead of ART. Saving more time than the conventional method, HT can also be considered a method of choice for uncooperative children. The concern over excess overbite in HT was observed to resolve at six- and 12-month recalls. Gallagher et al. also considered that changes in occlusion after placement of SSC will normalize after one month.[29] In a review of several studies, Innes et al. also reported a resolution of excess overbite and found no evidence of the child being concerned about excess overbite or experiencing temporomandibular joint pain.[30]

It is suggested that, in future studies, evaluation of a child's behavior should be blind to the treatment type. In the present study, the practitioner was the evaluator of the child's behavior; hence, this person could not be blind to the treatment, and it was a limitation of this study. The authors believe that further studies with larger sample sizes and longer follow-up times are required to confirm their preliminary results.

Conclusions

Based on this study's results, the following conclusions can be made:

1. The Hall technique has acceptable clinical and radiographic results comparable to that of the stainless steel crown technique for treatment for carious primary molar teeth with multisurface lesions.
2. A decrease of canine overbite occurs at the time of treatment in the HT group. However, alterations to overbite subside by six months after treatment.
3. The clinical and radiographic performance of modified atraumatic restorative treatment was not satisfying for the treatment of multisurface caries of primary molars.
4. More evidence is required for clinical use, especially regarding children's comfort and acceptance of HT.
5. Considering acceptable clinical and radiographic results and other advantages of HT, including less treatment time, technique simplicity, and showing high parental satisfaction, HT offers a treatment option for treatment of multisurface caries of primary molars.

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