

Cost-effectiveness and Acceptance in Children and Parents of the Hall Technique: Systematic Review of Clinical Trials

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ABSTRACT

Aims: The purpose of this systematic review was to evaluate the cost-effectiveness and acceptance of children and their parents of the Hall technique (HT) for dental rehabilitation in pediatric dentistry.

Background: The approach of the HT is that of minimally invasive treatment of the dental element and is used exclusively on primary molars. Various studies in the literature point to HT as a restorative option well accepted by children and parents and quite predictable, with low retreatment rates and good cost-effectiveness for the management of primary molars with carious lesions. However, no systematic review in the literature has approached randomized clinical trials on these topics to produce a high level of evidence and help establish clinical HT protocols.

Review results: Eight articles were selected for the systematic review. The HT was more cost-effective than procedures using other restorative materials. Regarding acceptance, in terms of esthetics, high percentages of satisfaction were reported for parents and children, with a divergence between studies in the comparison of esthetic preference with atraumatic restorative treatment. However, when considering crown cementation pain, comfort, anxiety, preference, and satisfaction, the HT was generally better evaluated when compared to other restorative materials.

Conclusion: The HT is an excellent restorative option when considering cost-effectiveness and acceptance and is recommended for use in daily clinical practice.

Clinical significance: Results indicate that HT is superior to other restorative materials regarding its acceptance by children and parents in terms of pain, comfort, anxiety, and crown preference and satisfaction. There were also high percentages of satisfaction with esthetics. Hall technique may initially appear expensive for dentists, but its effectiveness over time and the lesser need for consultations and reinventions ensure better cost-benefit than other restorative materials.

Keywords: Cost-effectiveness evaluation, Dental caries, Dental restoration, Permanent, Patient acceptance of health care, Systematic review.

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INTRODUCTION

Treatment of dental caries in primary and permanent teeth has traditionally involved the identification of lesions followed by clinical intervention to remove and restore affected enamel and dentin. However, there is currently enough evidence to recommend that the approach to caries lesions should primarily involve disease prevention and remineralization of dental elements.^{1,2}

When a carious lesion requires treatment of the dental element, a minimally invasive philosophy should be considered among non-invasive, microinvasive, invasive, and mixed approaches.² The mixed technique includes the Hall technique (HT), a procedure that alters the environment of the carious lesion, isolating it from the cariogenic biofilm and thereby preventing its progression.³⁻⁶

Hall technique is a technique used exclusively in deciduous molars, in which a prefabricated stainless-steel crown is cemented over the tooth to seal carious lesions in dentin without the need for anesthesia, carious tissue removal, and tooth preparation. The crown size is preselected and the crown is cemented over the decayed tooth element using glass ionomer cement with digital pressure or the force of the child's occlusion. The objective is for the crown to seal the lesion so that there is no contact with the fermentable carbohydrates in the diet, and the lesion slows down or paralyzes its progression, allowing the maintenance of the healthy deciduous element until the moment of its exfoliation.^{5,7,8}

There are several studies in the literature that point to HT as a restorative option that is well accepted by children and parents and predictable, with low retreatment rates and good

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cost-effectiveness for the management of deciduous molars with carious lesions.^{2,9-15} The hypothesis of this work is that the HT is well accepted by children and parents and presents a good cost-effectiveness ratio. There is still no systematic review of randomized clinical trials on these subjects in the literature that could produce a high level of evidence to help determine clinical protocols for HT. Therefore, the objective of this study was to evaluate the acceptance of children and their parents and the cost-effectiveness of the HT.

METHODS

The present systematic review was designed and conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA: <http://www.prisma-statement.org/>) and was recorded prior to its conduct in the International Prospective Register of Systematic Reviews (PROSPERO 2019 CRD42019133055: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42019133055).

Sources of Information and Search Strategies

A detailed search of PubMed databases via Medline, Sci Verse Scopus, Web of Science, Cochrane Library (Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials [CENTRAL], Cochrane Methodology Register), Latin American and Caribbean Literature in Health Sciences (LILACS) via BIREME Virtual Health Library, Excerpta Medica Database (Embase) and Grey Literature on Open Gray was performed to identify studies included in this review. Ongoing trials were searched in the US National Institutes of Health Clinical Trials Database (<http://ClinicalTrials.gov>).

Reference lists of selected articles were also checked to identify additional relevant studies. In addition, authors of unpublished studies were contacted to collect missing data, and alerts were created in the databases regarding newly published articles related to the research during the period of active searches (April 2020–February 2022). The research was based on the PICO strategy: P, population (children); I, intervention (HT and steel crowns); C, comparison (other restorative treatments); and O, result/outcome (cost-effectiveness and acceptance). Thus, the research question was structured as follows: “How well do children and parents accept the HT and what is its cost-effectiveness?” The search strategy used in each database can be found in Annex B. Medical subject headings (MeSH) descriptors and related words were used. The last inclusion of articles was carried out on February 24, 2022.

Article Eligibility Criteria

Parallel-group or split-mouth randomized controlled trials that evaluated the cost-effectiveness of the HT and/or the acceptance of steel crowns by children and/or parents (HT or CT) were included.

Non-human studies, *in vitro* or *ex vivo* studies, reviews, cohort studies, case-control studies, cross-sectional studies, case reports or series, and expert opinions were excluded. There was no restriction on publication date or language.

Selection of Articles

The studies retrieved by searching the databases with the predetermined search strategies were included in the Mendeley program to cross-reference the results and eliminate intra- and inter-base duplicates. Then, two independent reviewers (FBV and VCC) read the titles and/or abstracts of the papers and selected the studies that potentially met the inclusion criteria.

The full text of these potentially eligible studies was retrieved and independently assessed for eligibility by the two review team members (FBV and VCC). Disagreement between them at any time regarding the inclusion/exclusion of studies was resolved through discussion with a third reviewer (KMSM). Studies that did not meet the inclusion criteria were recorded in the section of studies excluded from the review, and the reasons for exclusion were noted.

Data Extraction

Two investigators (FBV and VCC) extracted data independently using a standardized pilot form, and any disagreements were resolved by discussion with a third investigator (KMSM): Reference, country, sample size, the age range of children, mean age, duration of intervention, intervention follow-up time, dropout rate, experimental and control groups, evaluated outcome (pain, esthetics, comfort, anxiety, satisfaction, preference, cost, effectiveness, and cost-effectiveness) and results found. In cases of missing data, the authors were contacted by email.

Risk of Bias Assessment

Risk of bias was independently assessed by two researchers (FBV and VCC) according to the Cochrane Handbook for Systematic Reviews of Interventions Version 6.2 using the Revised Cochrane Risk-of-bias Tool for randomized trials (RoB 2) (<https://training.cochrane.org/handbook/current/chapter-08>).¹⁶ They compared assessments and resolved disagreements through discussion with a third researcher (KMSM) when necessary. According to the document, the risk of bias for each study was assessed based on (1) Randomization process, (2) Deviations from the intended interventions, (3) Missing results data, (4) Measurement of the result, (5) Selection of the reported result.

Data Analysis

Texts and tables were used to provide a descriptive summary and explanation of the characteristics and findings of the studies.

RESULTS

Selection of Articles

The process for selecting the articles included in this systematic review is illustrated in the PRISMA flowchart in [Flowchart 1](#).

The initial electronic searches retrieved 655 works: 252 in PubMed (Medline), 110 in Scopus, 25 in Web of Science, 69 in Cochrane Library, 107 in Lilacs (Bireme), 61 in Embase, 0 in OpenGrey and 31 in Clinical Trials, of which 228 were excluded after analysis of duplicates, leaving 427 for title and abstract reading. This evaluation resulted in 23 studies. A search alert for the databases resulted in 128 articles, but after reading the titles and abstracts, none were included. After evaluating the full texts, 15 were excluded and 8 were selected as eligible for the systematic review. Annex C contains the list of excluded articles and reasons for exclusion. The reference lists of selected articles were read, but no additional eligible articles were found. After data extraction and analysis of the selected articles data, no scope was found to carry out a meta-analysis; therefore, a narrative analysis of the data was performed.

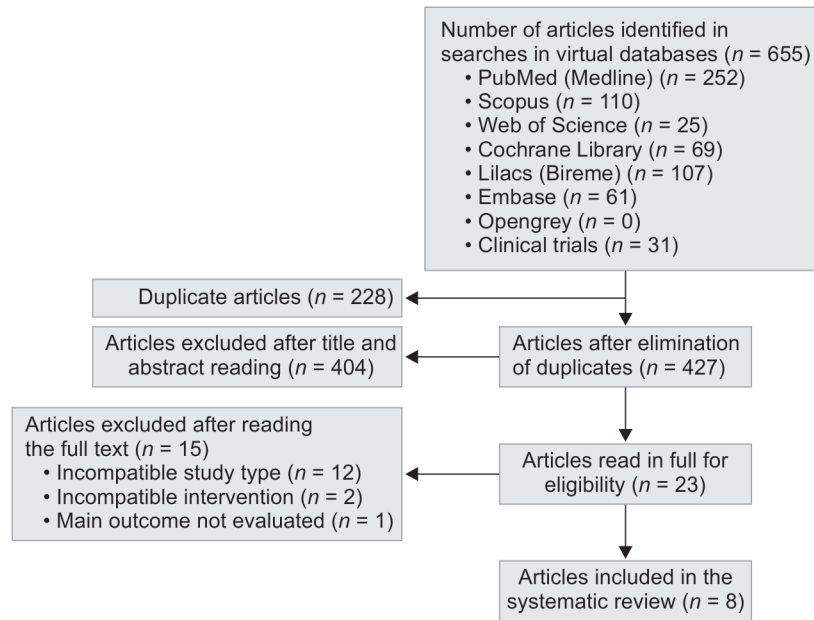
Description of Articles

The characteristics of the articles included in the systematic review and their results are described in [Table 1](#).

All studies were randomized clinical trials conducted in different countries: Brazil, Sudan, Iran, India, Scotland, and Germany.^{2,10,11,13,17–20} All articles were published in English between 2007 and 2020 and covered deciduous molars. The ages of the children involved in the studies ranged from 3 to 10 years.

Of the eight articles included, five assessed the acceptance of children and parents,^{10,13,17,18,20} one assessed acceptance and cost-effectiveness and two assessed the cost-effectiveness of the HT compared to other restorative techniques.^{2,11,19}

Flowchart 1: Study selection flowchart



Regarding acceptance, each article evaluated one or more parameters. Pain was evaluated in four studies.^{13,17,18,20} Esthetics, child discomfort and satisfaction were assessed by two articles each, and anxiety and preference in one article each.^{10,13,17–20}

Regarding the intervention groups of the clinical trials, the HT was compared with atraumatic restorative treatment (ART) in two articles with the conventional steel crown technique (CT) in one article, with modified atraumatic restorative treatment (mART) and CT in one article, with non-restorative treatment (NRT) and conventional restoration (CR) in two articles that are spin-offs of the same clinical research and with CR in two other articles that are spin-offs of the same clinical research.^{2,10,11,13,17–19}

The eight studies together included 749 children and 921 teeth (excluding studies that derived from the same research). Five studies included one tooth per child, one study included more than one tooth per child, and two had split mouths.^{2,10,11,13,17,18,20}

Only two articles did not report the average age of participants, and among those that did, it ranged from 5.6 (SD 1.5) to 8.1 (SD 1.2).^{18,20}

The duration of the intervention was one to two consultations for all studies, varying according to whether the insertion of the elastic band was needed. In our analysis, we considered the follow-up time only for studies that evaluated cost-effectiveness, since this data is not necessary for the evaluation of acceptance, which was always evaluated immediately after the intervention. Follow-ups were performed for 24, 30, and 60 months.^{2,11,19} The treatment dropout rates at the end of follow-up were 22.16, 15.98, and 31%, respectively.

Risk of Bias in the Articles Evaluated

The risk of bias in the articles evaluated is summarized in Figure 1.

The final classification for three studies was low risk, with some concerns for five studies.^{2,10,11,13,17–20}

In the criteria for the randomization process, deviations from intended interventions, missing outcome data, and outcome measurement, all articles were classified as low-risk.

In the criterion of risk of bias in the selection of the reported outcome, five articles were classified as having some concerns.^{2,10,18–20}

In the study by Elamin et al.,¹⁹ registrations in the clinical trials were performed after the clinical research was carried out. The articles by Innes et al.¹⁰ and Schwendicke et al.² are derived from the same clinical research, which was also recorded retrospectively in the clinical trials, and it is not possible to know whether the numerical outcomes evaluated are likely to have been selected from multiple eligible outcome measures because the protocol does not cite which methods measurement would be used.

The studies by Ebrahimi et al.¹⁸ and Lakshmi et al.²⁰ do not cite the study records, and it was not possible to locate them when consulting Clinical Trials (clinicaltrials.gov).

Effects of Interventions

Acceptance

The results of article acceptance are summarized in Table 2.

In terms of esthetics, Lakshmi et al.²⁰ pointed out that 100% of the children accepted esthetics from ART and that 3% accepted the HT, a result with a statistically significant difference (they did not report *p*-values). Araujo et al.¹⁷ reported that 68.1% of parents were not bothered by esthetics of the HT and 82.2% for ART and that crown esthetics were a concern for 23.4% of parents in the HT and 4.5% in ART. For children, positive responses for the intention to show the tooth to friends were 86.1% for ART and 92.5% for HT. Regarding being happy when someone saw the tooth, positive responses were 73.9% for ART and 81.9% for HT.

Regarding pain, Araujo et al.¹⁷ reported that children reported significantly more postoperative pain with HT than ART ($p = 0.001$) when considering elastic separator insertion and crown cementation. Considering only the cementation of the crown, there was no difference between the HT and ART ($p = 0.055$). The percentage of negative responses for discomfort was high (more than 70% for HT and more than 80% for ART), that is, children in general did not feel great discomfort. Lakshmi et al.²⁰ pointed out a significantly higher

Table 1: Characteristics and results of the studies

| Author (year) country | Sample (n) | Age | Average age | Duration of intervention | Follow-up time | Dropout rate | Experimental and control groups | Outcome evaluated | Result outcome found |
|-------------------------------------|---|------------|---------------|---|---------------------|--------------|---------------------------------|---|--|
| Araujo et al. ⁷ Brazil | 131 children: 66 HT and 65 ART (1 tooth per child) | 5–10 years | 8.1 (±1.2) | 1 or 2 appointments (1–7 days apart) | | | HT and ART | Children's self-reported pain (Wong-Baker faces pain scale), children's and parents' esthetic perception, and parents' report of children's comfort | Postoperative pain: Greater for the HT than ART ($p = 0.001$) when considering the insertion of the separating elastic and cementation of the crown. Crown cementation only, difference between the HT and ART ($p = 0.055$). Even with the difference between the groups, the percentage of negative responses for pain was high (more than 70% for the HT and more than 80% for ART). Crown esthetics: Of concern for 23.4% of parents with the HT and 4.5% with ART; 68.1% were not bothered by HT esthetics and 82.2% with ART. Positive responses from children to show the tooth: 86.1% with ART and 92.5% with the HT. Happy for someone to see the tooth: 73.9% with ART and 81.9% with the HT. Parental response regarding children's comfort during treatment: 93.4% positive with ART and 95.7% with the HT. |
| Ebrahimi et al. ¹⁸ Iran | 123 children: 42 HT, 42 mART and 39 CT (1 tooth per child) | 4–9 years | Do not quote | 1 | | | HT, mART and CT | Child self-reported pain (Faces pain scale-revised) and parental satisfaction (1 question and four-point Likert scale) | Pain on the scale (0-2-4-6-8-10): HT 2.15 ± 3.47; mART 2.65 ± 3.77; CT 2.94 ± 4.24 ($p = 0.814$). Parents' satisfaction (1–4): HT 3.76 ± 0.634; mART 3.79 ± 0.565; CT 3.45 ± 0.978 ($p = 0.156$). |
| Elamin et al. ¹⁹ Sudan | 164 children: 86 children with 109 HT teeth and 78 children with 103 CT teeth | 5–years | 6.89 (±0.874) | 1 appointment (elastic separator for 2 h before cementation of the crown) | 24 months (2 years) | 22.16% | HT and CT | Anxiety (Facial image score) and cost-effectiveness | Significantly higher anxiety for CT than HT (< 0.001). In the immediate postoperative period, 0.92% responded negatively to the HT and 18.44% to CT (unfortunate and very unhappy). The HT was more cost-effective than CT (shorter clinical execution time and lower cost, with no statistical difference between the groups in terms of longevity). |
| Innes et al. ¹⁰ Scotland | 132 children: split mouth (128 HT and 128 CR) | 3–10 years | 6.8 (±1.58) | 1 or 2 appointments | | | HT and CR | Preference of children and their caregivers | HT was preferred by 77% of children and 83% of caregivers compared to CR ($p < 0.0001$). |

(Contd...)

Table 1: (Contd...)

| Author (year) country | Sample (n) | Age | Average age | Duration of intervention | Follow-up time | Dropout rate | Experimental and control groups | Outcome evaluated | Result outcome found |
|---|--|------------|--------------------|--|-----------------------|--------------|---------------------------------|---|--|
| Lakshmi et al. ²⁰ India | 30 children: 15 HT and 15 ART | 5–8 years | Do not quote | 1 or 2 appointments (3–5 days between) | | | HT and ART | Esthetic acceptability (Yes/No), child's pain (Facial pain scores) and children's satisfaction with treatment | Significantly higher esthetic acceptance with ART (100%) than the HT (3%). Significantly higher reported pain with ART than the HT ($p = 0.0015$). No significant difference in satisfaction between groups (86.67% ART and 66.67% HT). |
| Santamaria et al. ¹³ Germany | 169 children: 52 HT, 65 CR, 52 NRT | 3–8 years | 5.6 (± 1.5) | 1 or 2 appointments (2–3 days between) | | | HT, CR and NRT | Children's perception of pain and parents' opinions about children's comfort | Children reported low or very low pain for 88% of NRT, 81% of HT and 72% of CR procedures, with no significant difference between groups ($p = 0.11$). Parents reported very comfortable children for 75% or HT cases, 65% for CR and 61% for NRT, without statistical significance ($p = 0.46$). |
| Schwendicke et al. ¹¹ Germany | 142 children: 40 HT, 58 CR, 44 NRT | 3–8 years | 5.6 (± 1.5) | 1 or 2 appointments (2–3 days between) | 30 months (2.5 years) | 15.98% | HT, CR and NRT | Cost-effectiveness | The HT was more cost-effective than CR and NRT (longer survival and lower cost). |
| Schwendicke et al. ² Scotland | 132 children: split mouth (128 HT and 128 CR) | 3–10 years | 6.8 (± 1.58) | 1 or 2 appointments | 60 months (5 years) | 31% | HT and CR | Cost-effectiveness | The HT was more cost-effective than CR (longer survival and lower cost). |

ART, atraumatic restorative treatment; CR, conventional restoration; CT, conventional steel crown technique; HT, Hall technique; mART, modified atraumatic restorative treatment; NRT, non-restorative treatment



Fig. 1: Risk of bias of evaluated articles

Table 2: Results of articles for acceptance

| | Araujo et al. ¹⁷ | Ebrahimi et al. ¹⁸ | Elamin et al. ¹⁹ | Innes et al. ¹⁰ | Lakshmi et al. ²⁰ | Santamaria et al. ¹³ |
|--------------|---|-------------------------------|-----------------------------|----------------------------|------------------------------|---------------------------------|
| Esthetics | ART > HT** parents HT > ART** children | | | | ART > HT* | |
| Pain | HT > ART* (with elastic) HT = ART* (without elastic) | CT > mART > HT** | | | ART > HT* | CR > HT > NRT** |
| Comfort | HT > ART** | | | | | HT > CR > NRT** |
| Anxiety | | | CT > HT* | | | |
| Satisfaction | | mART > HT > CT** | | | ART > HT** | |
| Preference | | | | HT > CR* | | |

*Statistically significant, **No statistical significance, result only numerical

report of pain in ART than the HT ($p = 0.0015$); about 80% of children reported pain in ART and 20% in the HT. Ebrahimi et al.¹⁸ described a low level of self-reported pain and no statistically significant difference between the HT (2.15 ± 3.47), mART (2.65 ± 3.77), and CT (2.94 ± 4.24). Santamaria et al.¹³ pointed out that the report of low or very low pain by children was 88% for NRT, 81% for HT, and 72% for CR, with no significant difference between the groups ($p = 0.11$).

Regarding the parents' opinion about the children's comfort during treatment, Santamaria et al.¹³ reported that 75% of parents rated their children as "very comfortable" in the HT, 65% in CR, and 61% in NRT, without statistical significance ($p = 0.46$). Araujo et al.¹⁷ reported that 93.4% of parents responded that the child felt well during ART treatment and 95.7% concerning HT.

Elamin et al.¹⁹ demonstrated that children's anxiety about treatment was significantly higher for the steel CT compared to the HT (<0.001). In the immediate postoperative period, 0.92% of the

children responded negatively (unfortunate and very unhappy) to the HT and 18.44% to CT.

Lakshmi et al.²⁰ reported that 86.67% of children were satisfied with ART treatment and 66.67% with HT, with no statistically significant difference between groups. Regarding parental satisfaction, Ebrahimi et al.¹⁸ reported a mean level of satisfaction in the HT (3.76 ± 0.634), mART (3.79 ± 0.565) and CT (3.45 ± 0.978) groups, with no significant difference ($p = 0.156$).

Even though no new clinical trials have emerged since the period of this review, a more recent scoping review, conducted by Júnior et al.²¹ in 2023, corroborates these findings, demonstrating that HT was well-accepted by parents and caregivers.

When studying the preference of children and caregivers, Innes et al.¹⁰ observed that HT was preferred by 77% of children and 83% of caregivers when compared to CR, a statistically significant result ($p < 0.0001$).

Table 3: Results of articles for cost-effectiveness

| | <i>Elamin et al.¹⁹</i> | <i>Schwendicke et al.¹¹</i> | <i>Schwendicke et al.²</i> |
|--------------------|-----------------------------------|--|---------------------------------------|
| Final cost | HT < CT* | HT < CR < NRT* | HT < CR* |
| Effectiveness | HT = CT** | HT > NRT > CR** | HT > CR* |
| Cost-effectiveness | HT > TC | HT > CR and NRT | HT > CR |

*Statistically significant, **No statistical significance, result only numerical

Cost-effectiveness

The results of the articles concerning cost-effectiveness are summarized in Table 3.

Regarding the cost-effectiveness analysis, Elamin et al.¹⁹ observed that the HT required significantly less clinical execution time ($p < 0.001$) and lower cost ($p < 0.05$). For the HT, the mean procedure execution time was 9.1 minutes (SD = 2.87) and the unit cost was US\$2.45 (SD = 0.14). For CT, it was 33.6 minutes (SD = 10.61) and US\$7.81 (SD = 0.14), respectively. No statistical difference was observed between the groups in the longevity of the restoration after 24 months of follow-up. The incremental cost-effectiveness ratio (ICER) was US\$136.56 more for each precast steel crown installed in the CT compared to the HT per life year.

Schwendicke et al.¹¹ demonstrated that the HT had a longer survival (mean estimated; 95% CI: 29.7; 26.6–30.5 months) than NRT (25.3; 21.2–28.7 months) or CR (24.1; 22.0–26.2 months). The proportion of teeth not requiring reintervention was significantly higher for HT (93%; 84–100%) than NRT (70%; 57–83%) and CR (67%; 55–79%). Furthermore, the HT was significantly more economical (€66; 62–71) than CR (€83; 73–92) and NRT (€296; 274–318) considering cumulative costs. When considering the initial costs, the HT (€62.70) was similar to CR (€61.65), while NRT had lower costs (€33.64). The average annual cost of the HT was significantly lower (€29; 23–34) than CR (€61; 46–76) and NRT (€154; 139–169). Thus, the researcher pointed out that the HT was more cost-effective than the other two treatments studied.

Schwendicke et al.² pointed out that the HT had significantly longer survival (99%; 95% CI: 98–100%) than CR (92; 87%–97%) ($p = 0.007$). Initial costs for the HT (£22.85) were higher than for CR (£8.75). Considering retreatment costs and direct costs related to dental treatment, the HT was not significantly more cost-effective (£24.12; 23.04–25.24) than CR (£29.26; 17.11–46.42). In assessing indirect costs, which include time and travel costs, the HT was significantly cheaper (£8.25; 95% CI: 7.33–9.22) than CR (£19.06; 15.87–22.63). Finally, the cumulative total direct and indirect costs were significantly lower for the HT (£32.26; 95% CI: 30.83–33.98) than in CR (£48.91; 34.4–68.74) ($p < 0.05$). Thus, the article demonstrates that the HT was more cost-effective than CR, being less expensive and more effective, with an average ICER of £2.38 spent additionally while losing 1% of the survival of molars restored with CR.

DISCUSSION

This work evaluated the acceptance of steel crowns by children and their parents and the cost-effectiveness of the HT. The hypothesis of good acceptance and cost-effectiveness was confirmed.

Acceptance

The acceptance of HT by children and parents has been studied by other researchers, who found that this technique is generally well accepted.^{9,10,14,15,21–23}

Innes et al.¹⁰ suggested that children accept the HT well due to the fact that it does not require local anesthetics and a high- or low-speed engine as well as the relative speed of performing the procedure. On the other hand, some complaints related to this technique are discomfort with pressure on the cementation of the crown, the use of gauze during the procedure, the taste of the glass ionomer cement, and the pressure of the elastic separator.^{9,10,15}

In addition, acceptance of the treatment is also related to the acceptance of the care team itself, in which a friendly team establishing a relationship of trust with the child and the caregiver and involving them in the decision-making process presents better levels of satisfaction and lower levels of anxiety with treatment.^{9,15} In this sense, the establishment of effective communication is presented as a fundamental factor to improve cooperation in general with the treatment, and therefore, dialogue and children's opinions have been increasingly emphasized in dentistry works.²⁴

Esthetics

Araujo et al.¹⁷ reported in their randomized clinical trial that HT treatments and ART were well accepted by children and parents. However, about a quarter of parents were concerned about the esthetics of the HT, while only 5% were concerned in the ART group, as well as Zimmerman et al.,²⁵ who reported that parents were concerned about the esthetics of steel crowns. However, for children, Araujo et al.¹⁷ reported greater percentages of esthetic satisfaction with HT than with ART, which differs from the results of Lakshmi et al.,²⁰ in which children esthetically preferred ART over HT. However, the sample of this study was small (30 children), and therefore the percentages are expressive. Bell et al.¹⁴ observed that steel crowns were well accepted esthetically by children and parents, as did Maciel et al.²² when comparing the HT with amalgam, composite resin, and ART.

Atraumatic restorative treatment is performed with glass ionomer cement, which is similar in color to the tooth, not making the intervention obvious, unlike HT, in which the steel crown is clearly noticeable. Socially, it can be understood as a lack of parental care for children's oral health.¹⁶ Kershaw et al.²⁶ corroborated the fact that caries lesions, in the layman's perception of adults, incur negative social judgments. However, is the esthetic decision of the treatment up to the parents or the patient who will use the rehabilitation?

Children often do not yet have the perception of social stigmatization of the history of restorative dental treatments as visible markers of dental caries experience, but as they enter adolescence, they begin to feel peer pressure to be "normal", although Lakshmi et al.²⁰ reported esthetic concerns on the part of children aged 5–8 years.¹⁵

In this sense, it is worth reflecting on the esthetic standards imposed by society and their influence on treatment planning. Should cases be planned based on the best option considering primarily functional benefit to the patient or esthetics? Zimmerman et al.²⁵ reported that when confronted by parents regarding the esthetics of a steel crown, 43% of dentists follow the parents' preferences, even when this action is contrary to their initial clinical judgment. Page et al.¹⁵ pointed out that initially, the esthetics of the steel crown were concerning for parents. However, after proper guidance regarding the importance and functionality, the work was carried out and none of the parents reported that their children were questioned; on the contrary, they reported that the children felt special.

Thus, we can include other dental issues in addition to restorative material in the discussion of esthetic intervention, such as enamel development defects and inactive caries lesions, which often do not require functional interventions and are not a nuisance to the child patient. Therefore, we can choose not to intervene or delay the intervention.^{27,28}

Pain

The findings by Araujo et al.¹⁷ and Lakshmi et al.²⁰ differed regarding children's pain response in comparing HT and ART, in which the first obtained statistical significance for greater pain in HT and the second in ART. However, it is worth mentioning that in the study by Araujo, when assessing pain without considering the insertion of the elastic band, there was no statistical difference between the groups, that is, the pain reported by the children was probably related to the insertion of the elastic band, and not to the performing the HT technique and cementing the crown itself.

Santamaria et al.¹³ reported similarly low pain levels for the HT, NRT, and CR, as well as Ebrahimi et al.¹⁸ who evaluated HT compared with the CT and mART (including the use of high- and low-speed drills and restoration with light-curing glass ionomer cement, different from ART, which uses hand instruments and chemical glass ionomer cement). Lakshmi et al.,²⁰ Ebrahimi et al.,¹⁸ and Santamaria et al.¹³ did not separate the analyses considering the insertion (or not) of the separator elastic. It should be noted here that in the four studies that evaluated pain, the percentage of responses indicating high pain was low; that is, children generally did not report much pain in the treatments evaluated (HT, ART, mART, CT, NRT, and CR).^{13,17,18,20} Page et al.¹⁵ described that most parents reported that their children did not feel pain during treatment, and the few that did experienced it during the crown test.

Comfort and Anxiety

In general, children felt comfortable with the restorative treatments of HT, ART, CR, and NRT, but felt more anxious about the conventional steel CT than HT, since CT involves the use of anesthesia (a factor of great concern for children due to the use of the needle), a motor (which produces noise) and the long clinical procedure (poorly tolerated by children).^{13,17,19,29,30} The technique for performing the HT is simple and quick, and therefore, the children probably felt less anxious.

Topaloglu-Ak et al.³¹ reported that anxiety about dental treatment leads to increased perceptions of pain and discomfort and uncomfortable treatments can also result in increased dental anxiety. Therefore, it is suggested that reducing the number of steps in the procedures, as in the HT, is of great value for reducing anxiety, and consequently, discomfort.

On the other hand, Ayedun et al.³² pointed out that HT had a significantly higher level of discomfort than CT. However, it is worth considering that the sample size of the study was small. It would be quite reasonable to consider the use of the HT in view of the benefits of preserving the dental element, especially considering its use in an environment with limited resources, where electricity and access to care are controversial issues. In Bhatia et al.'s work, 65% of patients reported little or no discomfort during the fitting of the crown, and in Taylor's work, reports of comfort exceeded 90%.^{23,33}

Preference and Satisfaction

When evaluating the preferences of children and caregivers, Innes et al.¹⁰ observed that HT was significantly preferred over CR. This preference may be due to the fact that the elastic separator, which

usually causes discomfort in patients, was used in only 13% of HT cases, and selective tissue caries removal was performed in CR, which may have included the use of drills and anesthesia at the discretion of the professional who performed it.³⁴ These factors may have caused discomfort, reducing the preference for this technique among children and caregivers.

Lakshmi et al.²⁰ found a high degree of satisfaction among children with ART and HT, with no significant difference between them. Maciel et al.²² reported satisfaction reports of more than 94% in the four groups evaluated, with no difference between them (composite resin, amalgam, ART, and HT), and BaniHani et al.⁹ also obtained a high satisfaction rate, with no difference between the HT and selective removal group compared to the total caries removal group. In addition to the children's satisfaction, a reasonable level of satisfaction was observed in the parents' reports in all groups in the study by Ebrahimi et al.¹⁸ (HT, mART, and CT). The high degree of patient satisfaction in all groups may be related to gratitude for resolving the patients' caries lesion problems and the relationship of trust with the dental team, which is essential for reducing the degree of anxiety and consequent cooperation with the treatment.

Cost-effectiveness

In the three studies included in the systematic review that evaluated cost-effectiveness, the HT proved to be more cost-effective than the other restorative materials (CT, CR, and NRT).

Schwendicke et al.¹¹ and Schwendicke et al.² showed that HT had greater survival than NRT and CR after 30 months of follow-up and CR after 60 months, respectively. Elamin et al.¹⁹ pointed out that the HT required less clinical time to perform and that survival was equal to CT at 24 months of follow-up. BaniHani et al.⁹ report more than a 95% success rate of restorations in the CR and HT groups after more than 9 months of follow-up, with no difference between the groups. Schwendicke et al.¹¹ analyzed the need for reintervention and found it to be significantly lower for HT than NRT and CR.

Page et al.¹⁵ reported that some parents preferred the HT for its longevity, as with less need for reinterventions, there would be less stress for children, lower costs for parents (who would need to take time off of work for the child's dental appointment and follow-ups, for example, and spend money on commuting) and for the health system.

For cost analysis, Schwendicke et al.² used a social payer perspective and included an analysis of direct costs (related to dental treatment) and indirect costs (time and travel). Schwendicke et al.¹¹ used a mixed public-private payer perspective and analyzed the direct costs of rehabilitation, and Elamin et al.¹⁹ only considered initial treatment costs. BaniHani et al.⁹ considered the initial costs of performing the treatment and the costs of retreatment.

Schwendicke et al.² pointed out that the initial costs of the HT procedure were higher than that of CR. However, the total direct and indirect cumulative costs over the course of follow-up were significantly lower for the HT. Schwendicke et al.¹¹ also pointed out that while initially, the HT required a higher cost than other materials when considering cumulative costs, the HT was the cheapest option. Elamin et al.¹⁹ calculated the cost of performing the procedures and reported that the HT was more economical, and BaniHani et al.⁹ reported almost twice the cost for the CT group as for the HT group.

Limitations

Regarding the limitations of our systematic review, we emphasize that there is little standardization in the age of children in the included studies, the acceptance criteria, and the cost analyses

of the studies, which makes comparisons and meta-analysis difficult. In addition, the number of published randomized clinical trials evaluating the acceptance and cost-effectiveness of the HT compared to other restorative materials is low, so we suggest carrying out more studies with a similar methodology to achieve a standardized analysis of the results as well as other systematic reviews and meta-analyses.

CONCLUSION

Based on the results of this study, the HT presents as a restorative option with good acceptance in general for children and parents. Regarding esthetics, high percentages of satisfaction are reported for parents and children, with a divergence between studies in the comparison of esthetic preference with ART.

When considering crown cementation pain, comfort, anxiety, preference, and satisfaction, the HT is generally better evaluated compared to other restorative materials. With regard to cost-effectiveness, the HT at first may seem to the clinician to be an option with a high cost of execution, but when considering its effectiveness over time and the lower need for consultations and reinterventions, it appears more cost-effective when compared to other restorative materials.

Clinical Significance

The results of this study bring clinical significance that HT is superior to other restorative materials regarding its acceptance by children and parents in terms of pain, comfort, anxiety, and crown preference and satisfaction. There were also high percentages of satisfaction with esthetics.

Furthermore, HT may initially appear to have a high cost for clinicians, but when considering its effectiveness over time and the lesser need for consultations and reinventions, it has better cost-benefit than other restorative materials.

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