



Reports of pain by children undergoing rapid palatal expansion

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Abstract

Purpose: This study described and quantified the prevalence, timing, and intensity of pain during the expansion phase of rapid palatal expansion (RPE) in children and investigated whether pain was related to age, sex, or rate of expansion.

Methods: Ninety-seven children, 38 males and 59 females, between the ages of 5 to 13 years (median 7.7 years) undergoing RPE procedures with the Hyrax[®], Dentaaurum, Newtown, PA, appliance were surveyed. The appliance was expanded with either one or two turns (1/4 mm/turn) per day based on the provider's preference. The child's pain response was measured no more than 5 minutes after each turn for the entire period of expansion using both the Facial Pain Scale and the Color Analog Scale.

Results: Ninety-eight percent of the children reported at least some pain during RPE. The highest levels of pain were reported during the first 10 turns with the greatest intensity during the first 6 turns and a steadily decreasing amount of pain thereafter. Pain medication was taken after 7% of the expansion turns in the study with the majority of children taking the medication during the first 6 turns. Forty-eight percent of the children took pain medication at least once during the expansion phase of RPE. There was no difference in either reported pain or use of pain medication based on age, sex, or stage of dentition. During the first 10 turns, children whose rate of expansion was two turns/day were more likely to report pain and take pain medication than children whose rate of expansion was one turn/day, thereafter there were no differences.

Conclusions: The vast majority of children undergoing the active phase of rapid palatal expansion with a Hyrax[®] appliance report pain. The pain generally occurs during the initial phase of expansion and diminishes thereafter, with two turns/day resulting in reports of pain greater than those expanding only once/day. (*Pediatr Dent* 22:221-226, 2000)

Rapid palatal expansion (RPE) is a common orthodontic procedure used to correct maxillary arch constriction by opening the mid-palatal suture. This procedure is commonly used to correct posterior crossbites in the primary, mixed, or permanent dentition. This is a common malocclusion in children with a reported prevalence ranging from 7.1 to 23.3%.¹⁻⁴



Fig 1. Hyrax[®] appliance seated on the maxillary first permanent molars and first primary molars.

Several types of fixed appliances are commonly used to correct posterior crossbites by widening the mid-palatal suture. These include the Haas expander, Minne expander, Hyrax[®], quad helix, as well as removable expanders. The Hyrax[®] appliance is one of the more common types of RPE appliances currently used to correct posterior crossbites. It is a hygienic, fixed metal appliance with a nonspring-loaded jackscrew, which is attached to either 2 or 4 teeth (Fig 1). The abutments may be the primary canines, primary molars, permanent premolars, or molars depending on the age of the individual. The expansion screw is turned with a key either once or twice daily (1/4 mm expansion/turn) for the entire expansion phase of treatment which usually lasts from 2-4 weeks. RPE utilizes large forces to produce maximal orthopedic repositioning with a minimum of orthodontic movement. A single activation of the expansion screw produces approximately 3-10 pounds of force.⁵ Since RPE is a common orthodontic intervention when the maxillary dental arch requires orthopedic expansion, many aspects of this procedure have been investigated in depth and are described in the dental literature.⁶⁻¹²

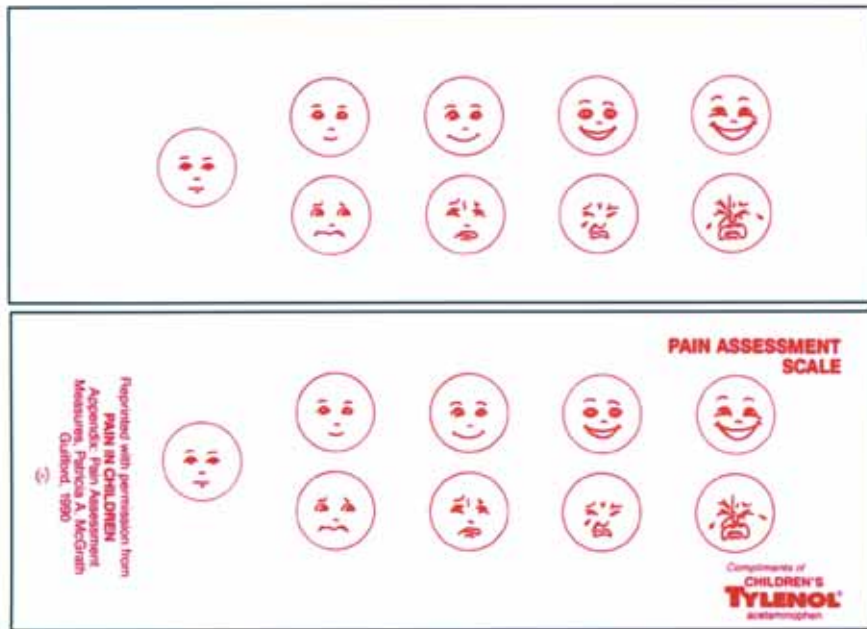


Fig 2. Facial Pain Scale.

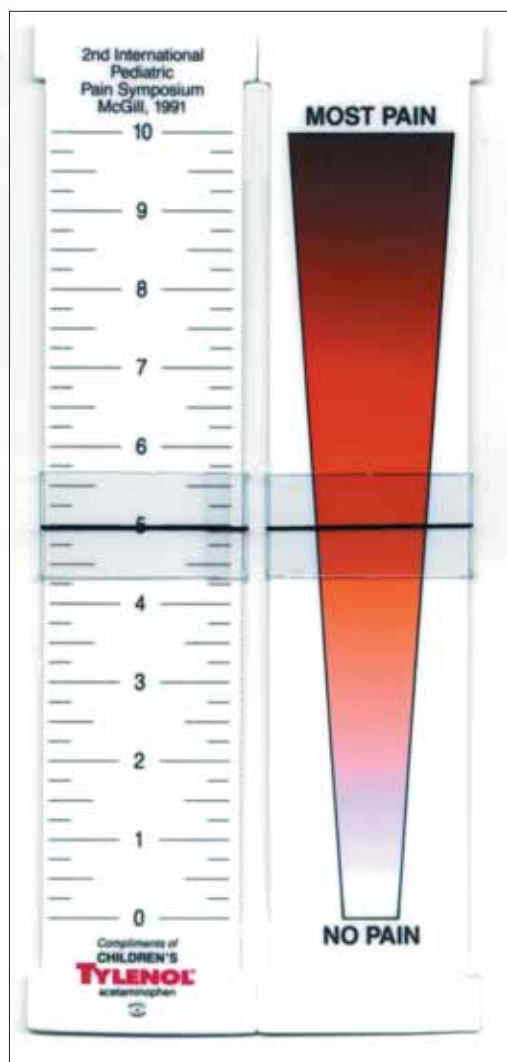


Fig 3. Color Analog Scale.

Clinicians using RPE procedures are aware that children frequently report pain during the expansion phase of treatment. However, there is no literature available documenting this occurrence. The purpose of this study was to investigate the prevalence, timing, and intensity of pain during the expansion phase of RPE in children and to further ascertain whether pain is associated with age, gender, or rate of expansion.

Materials and methods

Subject selection

Children under the age of 14 years old who were undergoing RPE between August 1996 and June 1998 in two private pediatric dental offices (5 pediatric dentists) were asked to participate in the study. All patients demonstrated either unilateral or bilateral dental crossbites as

a result of maxillary constriction in either the primary, mixed, or permanent dentition and were undergoing RPE with a Hyrax[®] appliance. The Hyrax[®] was the primary appliance of choice for expansion by the five providers and was the only appliance used in this study for consistency of expansion effects. Mental disability, current use of pain medication, chronic illnesses, presence of other oral pathology, inability to speak English (either parent or patient), or failure to give informed consent were criteria for exclusion. The Committee on Clinical Investigation of Children's Hospital, Boston, approved the protocol. Parents gave informed consent and children gave assent for participation in the study.

Procedure

The Hyrax[®] appliance was expanded either 1 turn (1/4mm) or 2 turns (1/2mm) per day. The subjects were not randomly assigned to these two treatment groups, but rather selection was based on individual provider preference. Selection criteria for the individual's preference of 1 or 2 turns per day were not ascertained. An introductory and explanatory letter about the study was given to the parents of children who were invited to participate in this study.

Along with the introductory letter explaining the study and protocol, verbal instructions were given to the parent and child on how to utilize both the Facial Pain Scale (FPS)¹³ and the Color Analog Scale (CAS).¹⁴ The first expansion was performed in the dental office and the child was asked to rate his/her perceived pain using both pain scales immediately after the expansion was performed. The parents were asked to repeat the expansion procedure and pain measurements at home for the remaining turns. The child's pain response, immediately after the parent completed turning the screw, was recorded on a data collection sheet for the entire phase of expansion.

The FPS and CAS were developed in part because children below ages 7-8 have difficulties with the standard visual analog scales (VAS) commonly used for adults.¹⁵ The FPS measures the unpleasantness or affective dimension of a child's pain experience and is used in children ages 3-17 years old. The child

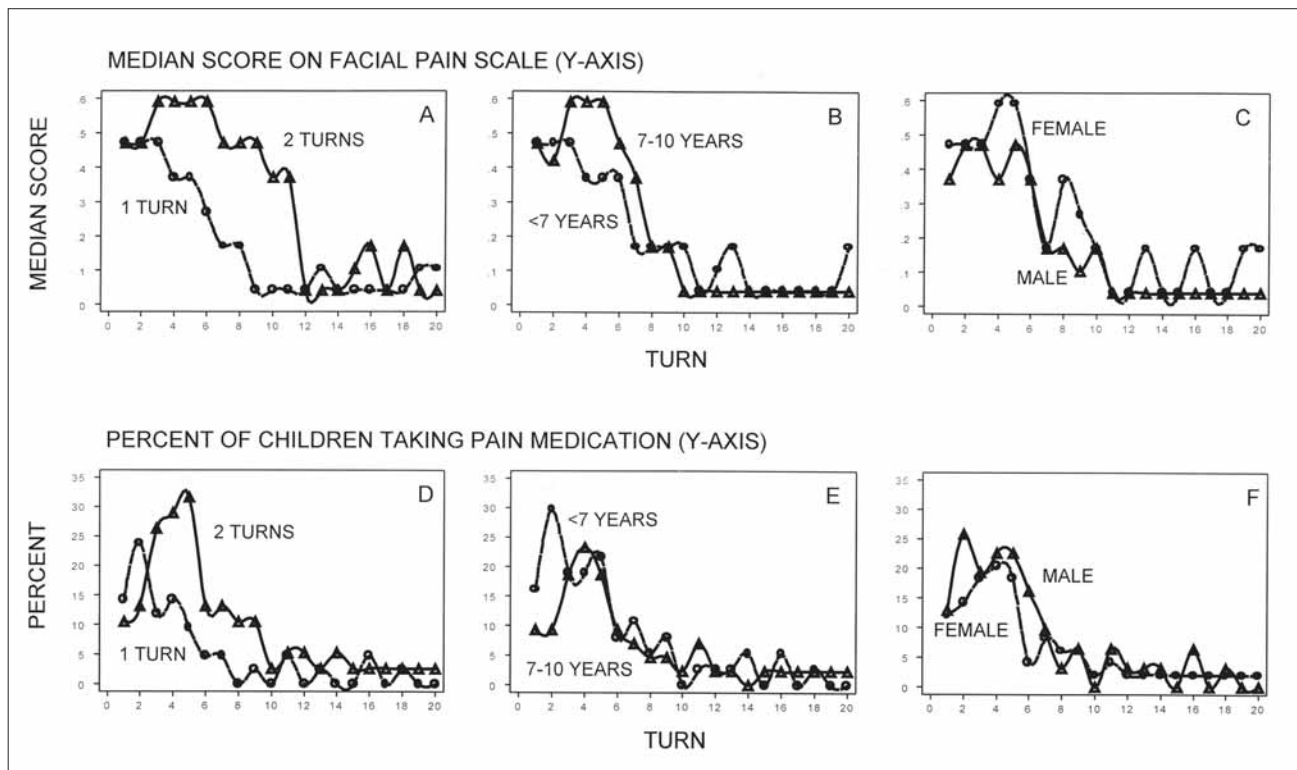


Fig 4. Pain reports and use of pain medication as a function of expansion rate, age, and sex.

is shown a set of nine cartoon faces with varying facial expressions ranging from a smile/laughter to that of tears (Fig 2). Each face has a numerical value where “0” equals the maximum positive affective value and “1” the maximum negative affective value. The child then selects the facial expression that best represents his/her experience of discomfort. The child is asked to select the face “which looks like how you feel deep down inside, not the face you show to the world.” The facial pain scale shows good construct validity as a self-report pain measure.¹³ The CAS measures the strength of a child’s pain experience. It is a slide-rule type device (Fig 3) on which the child is asked to slide the marker along a scale that ranges between light pink and dark red where the darker the color, the greater the pain experience.^{14,16} The child is asked to “slide the marker along the scale until the intensity of the color matches the strength of your pain.” *No pain* is at the bottom and *Very painful* is at the top of the scale. A numerical ruler is printed on the opposite side of the measuring tool so that the child’s self-reports in color can be converted to numerical scores ranging from 0 to 10. Previous work from our group has shown that the CAS shows excellent agreement with a different facial expression scale, the Oucher,¹⁷ in a sample of 3-7 year old children following surgery.¹⁸

Data analysis

The patient’s date of birth and date that the expansion started were recorded on the data collection sheet. Each child’s pain response was recorded, as well as the use of any pain medication at any time during the expansion phase. Missed turns and the reason for missing the turn were also recorded. Forms were collected at the end of the expansion phase of the treatment and the data were entered into STATA® Version 6 (Stata Corp., College Station, TX).

Participants were segregated into categories of age (less than 7 years of age, 7-10 years of age, and greater than 10 years of age) and rate of expansion (1 turn/day vs. 2 turns/day). Fisher’s exact test was used to examine relationships between rate of expansion, pain medication intake, age, and sex. The Spearman correlation coefficient was used to evaluate the relationship between the pain scales at each turn. A cross-sectional time series logistic regression model that takes into account the correlation of serial measurements in the same subjects was used to evaluate the contributions of rate of expansion, sex, and age to reported pain.

Results

A total of 103 children participated in the study. However, six subjects were excluded due to incomplete data. Of the remaining 97, 61% were females and 39% were males. The age range was 5 to 13 years old with a median age of 7.7 years. The dentitional stage was primary in 43%, mixed in 28%, and permanent in 29%. There was a significant correlation between the CAS and FPS pain scales for each turn (correlation coefficient ranged from 0.69 to 0.88, all $P < 0.0001$). For clarity and simplicity, the results are presented only using the FPS pain scale. In addition, the pain scores for only the first 20 turns were used in the analysis because the total number of subjects who reported pain during turns later than turn 20 was small.

The age categories used (less than 7 years of age, 7-10 years of age, and greater than 10 years of age) closely paralleled the expansion of either the primary, mixed, or permanent dentition. There were few subjects in the greater than 10 years of age group (17.5%; 17/97). Children in the participating practices tend to be expanded at earlier ages, leaving few older patients in need of this treatment. Of these 17 children, only

5 were expanded at the rate of 2 turns/day compared to 12 at 1 turn/day. This may be due to the dentists' belief that the mid-palatal suture is less pliable and thus more painful to expand twice per day in older children. We excluded children over 10 years from our analyses since we could not separate the age and turns-per-day effects. Thus, our final analyses are based on 80 children. There were no significant differences between the rate of expansion and either gender ($P=0.36$), age ($P=0.32$), or stage of dentition ($P=0.13$).

Over the entire course of the expansion, 98% (78/80) of the children reported some pain. There was no statistically significant difference between females and males in median reported pain scores. The maximum reported pain occurred during the first 6 turns, and a steadily decreasing amount of pain was reported thereafter.

Pain medication (Children's Tylenol,[®] Advil,[®] or Motrin[®]) was taken after 7% (116/1484) of the turns. Sixty-nine percent (80/116) of the time pain medication was taken it occurred during the first 6 turns. Forty-eight percent (38/80) of the children took medication at least once during the expansion.

The top panel of Fig 4 (A-C) illustrates the median scores of reported pain over the course of expansion as a function of rate of expansion (Fig 4A; 1 turn/day vs. 2 turns/day), age categories (Fig 4B; < 7 years vs. 7-10 years), and sex (Fig 4C; males vs. females). Regardless of rate of expansion, child's age, and sex, reported pain decreased significantly with time ($P<0.0005$). Children whose rate of expansion was 2 turns/day were 2.1 times (95% CI: 1.2, 4.0, $P=0.02$) more likely to report pain than children whose rate of expansion was one turn/day. When the first 10 turns were examined, children whose rate of expansion was 2 turns/day were 3.0 times (95% CI: 1.3, 4.1, $P=0.004$) more likely to report pain than children whose rate of expansion was 1 turn/day. There was no difference in reported pain during the last 10 days of turns (turns 10-20) ($P=0.23$). There was no difference in the reports of pain based on age or sex.

The bottom panel of Fig 4 (D-E) illustrates the percent of children taking pain medication over the course of expansion as a function of rate of expansion (Fig 4D; 1 turn/day vs. 2 turns/day), age categories (Fig 4E; <7 years vs. 7-0 years), and sex (Fig 4E; males vs. females). Children whose rate of expansion was 2 turns/day were 2.0 times (95% CI: 0.97, 4.3, $P=0.06$) more likely to take medication than children whose rate of expansion was 1 turn/day, although difference failed to reach nominal statistical significance. When only the first 10 turns were analyzed, children whose rate of expansion was 2 turns/day were 2.1 times (95% CI: .98, 4.4, $P=0.06$) more likely to use pain medication than children whose rate of expansion was 1 turn/day. There was no difference in the use of pain medication during the last 10 days of turns (turns 10-20) ($P=0.32$). There was no difference in the use of pain medication based on age or sex.

Discussion

Although numerous articles have reported the pain associated with various types of orthodontic procedures such as separator placement, initial, and routine arch wire placement,¹⁹⁻²³ none have reported on the pain associated with RPE. The purpose of this study was to investigate the prevalence, timing, and intensity of pain that children experience during RPE to add clinicians in preparing their patients and their parents for this

procedure. It is difficult to compare the results of this study using rapid orthopedic forces to those studies previously cited which evaluated pain associated with lighter orthodontic forces. In addition, too many variables exist among these investigations such as subject age, type of arch wires used, and type of malocclusions to make valid comparisons.

Documenting and measuring pain in children can be difficult and has led to extensive research in this field.²⁴⁻³³ The most highly developed method for measurement of pain in the pediatric population is the child's subjective report of intensity. Studies have shown that children 3 years and older are capable of understanding the concept of hurt and its varying degrees of intensity, if provided an appropriate device for doing this.²⁴ Our study used two common, validated pain scales, the Facial Pain Scale (FPS) and the Color Analog Scale (CAS). Previous work showed agreement of FPS or CAS with the standard VAS scales in children old enough to perform both scales properly.^{14,16} Oncology patients aged 3-15 years old evaluated pain produced by necessary medical procedures on a VAS and FPS.²⁶ The intensity of pain as rated on both scales varied as expected with the intensity of pain expected with the procedure. Maunuskele et al.²⁷ reported the validity of using the VAS and FPS in children to rate postoperative pain. Children ages 6-8 were able to rank a series of faces in order of increasing pain.²⁸ In a pilot study by Tyler et al.,²⁸ the FPS and VAS conformed to the predicted trend for pain following surgery. In addition, these scales were correlated with each other.

This study suggests that most children undergoing this very common orthodontic procedure experience some pain, usually during the early phases of expansion. According to Zimring et al.,¹⁰ the maximum load produced by any single activation occurs immediately at the time of the turning of the jackscrew and begins to dissipate soon thereafter. Human and animal studies have shown that when sutural tissues are expanded rapidly, highly vascular disorganized connective tissue of an inflammatory nature is created, which results in the perception of pain.³⁴⁻³⁶ Cleall et al.³⁴ report that the midpalatal suture widened very soon after the application of pressure in the rhesus monkey. As expansion continued, less disruption of the midpalatal tissues occurred with each progressive turn of the screw. That observation may explain the decrease in reported pain by the children in this study. The decreasing trend in reported pain may also be explained by the fact that children may become more comfortable with the procedure, and thus the fear and anxiety of turning the appliance may be lessened with each turn.

In this study, children 7-10 years of age were no more likely to report more pain or to use pain medication during RPE compared to children less than 7 years of age. Studies assessing pain and its association with age are conflicting. Goodenough et al.³⁸ reported that younger children reported more pain than older children during venipuncture did. A study by Scott et al.,²⁵ which measured pain in children, aged 5 years and older with juvenile chronic polyarthritis found no significant correlation between pain score and age. In a study by McGrath et al.,²⁶ there was no difference in pain reports in children with cancer undergoing necessary medical procedures when analyzed by age. Katz et al.³⁹ demonstrated that younger children with leukemia show greater acute behavioral stress during routine lumbar punctures compared to older children. Although younger children in our study reported no less pain

than older children, they were less likely to take pain medication. Some laboratory studies suggest that sutural expansion should be more easily performed in younger children, thus potentially causing less pain and reducing the need for pain medication. A study in cats showed that the sutural bone cells of young cats were more responsive to palatal expansion forces than those of older animals.⁴⁰ A relationship between increased resistance to skeletal expansion and increased patient age has been quantified. In a study by Wertz et al.⁴¹ older patients undergoing maxillary expansion for correction of bilateral maxillary narrowness demonstrated a lesser degree of skeletal alterations than the younger patients did. The resistance to expansion stems not from the midpalatal suture itself but from other maxillary articulations. In our study, children who were expanded twice per day had significantly higher pain reports and tended to take more analgesics. Several previous studies of pediatric outpatient surgery suggest that parents are reluctant to give their children pain medications even when encouraged to do so, and even when pain assessments are done. A study which evaluated the adequacy of pain medication in children undergoing minor, uncomplicated surgery showed that over half of the subjects were undermedicated for postoperative pain, being required to suffer pain that was above their treatment threshold.³⁷ Chambers et al.⁴³ evaluated the agreement between child and parent reports of pain in children following minor surgery and found that parents demonstrated low levels of sensitivity in identifying when their children were experiencing clinically significant pain which may contribute to inadequate pain control.

In this study, the sex of the child was not a significant factor in either predicting reported pain or use of pain medication during RPE. Based on other studies of pain in children, sex does not appear to be a significant factor. McGrath et al.²⁶ reported no difference in reported pain between girls and boys with cancer undergoing necessary medical procedures. In a study by Hogeweg et al.,⁴⁴ mechanical pain thresholds were not different among boys and girls aged 6-17 years old who had pressure applied to the elbow, wrist, knee, ankle, and paraspinally.

Measurements of pain in children through self-reports must be interpreted cautiously. Pain can be difficult to measure due to limited language skills, developmental factors, different attitudes towards pain, and prior pain experiences. However, with proper utilization of a valid pain scale, such as the FPS or CAS and properly designed studies, the factors associated with painful medical or dental treatments performed on children can be identified. This study supports an alternative, less painful RPE regimen for children. The appliance might be expanded at a rate of only 1 turn/day for the first 10 turns when the pain is most intense and then at 2 turns/day for the remaining period of expansion when there is no apparent difference in pain between 1 or 2 turns/day. Another alternative would be to decrease the rate of expansion to a half turn (1/8 mm) per day for the first 10 turns. These findings provide clinicians with information to more accurately inform parents and children about the likelihood, timing, and intensity of pain during RPE.

Conclusions

1. Ninety-eight percent of children reported at least some pain during rapid palatal expansion (RPE).

2. The highest levels of pain were reported during the first 10 turns with the greatest intensity during the first 6 turns and a steadily decreasing amount of pain thereafter.
3. Pain medication was taken after 7% of all expansion turns in the study, with the majority taking the medication during the first 6 turns.
4. Forty-eight percent of the children took pain medication at least once during the expansions phase of RPE.
5. There was no difference in either reported pain or use of pain medication based on age, sex, and stage of dentition.
6. During the first 10 hours, children whose rate of expansion was 2 turns/day were more likely to report pain and take pain medication than children whose rate of expansion was 1 turn/day; thereafter there were no differences.

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