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Radiographic Pattern of Colon Transit Time in Iranian Children with Constipation

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Abstract

Background

Studies on colonic motor function in pediatric patients with constipation have revealed some dysfunctional patterns of colonic transit. The aim of this study was to evaluate the times and patterns of colon transit time to diagnose and categorize of colon abnormalities.

Materials and Methods: This descriptive, cross-sectional study was performed at Dr. Sheikh Pediatrics Hospital of Mashhad University of Medical Sciences, Mashhad, Iran during 2013-2019. Sixty-four children with chronic constipation that were referred to the radiology department were enrolled in the study. Segmental and total colon transit times (CTT) were calculated by using plastic markers and Metcalf Protocol. Data were analyzed using SPSS software (version 22.0).

Results: Among 64 children with constipation (aged between 2 and 18 years), about half (51.5%) of patients had normal segmental and total CTT. Of 43 patients with a normal total CTT, 10 (23%) had a prolonged segmental CTT. the normal upper limits of CTT were considered for the right colon, left colon, rectosigmoid, and total colon at 20, 20, 30, and 60 hours, respectively. These times had a 97% specificity with AUC = 0.74 to 0.93 to differentiate the normal from the abnormal transit time. The transit abnormalities were included rectosigmoid retention (22%), colon inertia (17.2%), left colon retention (6.2%), and right colon retention (3.1%).

Conclusion

Both segmental and total CCT were found normal in half of our constipated patients and Rectosigmoid retention and colon inertia were the most common abnormalities. The normal upper limits for colon transit time in the northeast of Iran were less than those found in Western countries.

Key Words: Children, Constipation, Colonic transit time.

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1- INTRODUCTION

Constipation can be seen in both primary and secondary forms, and is one of the most common GI complaints in the whole world. It is the reason for %3 of outpatient visits and 1/4 of referrals to pediatric gastroenterologists (1). Childhood constipation worries the parents and causes frequent doctor visits (2). Most causes of constipation in children are functional and a few are organic. To explain such a clinical course, the main hypothesis is colonic transit dysfunction. Studies of colonic motor function have revealed dysfunctional patterns of colonic transit in pediatric patients with refractory constipation (1). Different patterns of delayed transit have been described and specific therapies have been proposed with good results (3). Colon transit time (CTT) by assessment of colonic motility disorders helps to differentiate the type of constipation, plan for treatment and determine the need for further studies. It can measure the transit time by use of radiopaque markers or by methods based on scintigraphy (4).

CTT is an easy, cost-effective and objective evaluation method, which helps to identify the pathophysiology of constipation (1). Colon transit time and dysfunctional patterns in each country is different due to differences in race and dietary regimen. Although the mean colon transit time was reported as 30-40 hours in most studies in Western countries and the upper normal limit was mentioned to be 60-70 hours (2), the mean CTT was 20-30 hours in healthy adults in Korea and China (2, 5), and 15.8 hours in healthy Indians population (6, 7). Two CTT studies have been previously performed in Iran on adults (8, 9), but we didn't find any similar studies on Iranian children with constipation. The aim of this study was to evaluate colon transit time and dysfunctional pattern in these patients.

2- MATERIALS AND METHODS

2-1. Study design and population

This descriptive cross-sectional study was performed at Sheikh Children's Hospital, Mashhad, Iran, during 2013-2019 on 64 children with chronic constipation without any other complaints. The patients were referred to the radiology department for colon transit time CTT examination.

2-2. Intervention

Since the CTT in normal and constipated children was unknown in the Iranian population, in a pilot phase, we first evaluated approximate colon transit time in a number of patients with single ingestion of markers on a specific day, followed by daily abdominal X-rays until markers were defecated. It is an old way of measuring time. After evaluating the times obtained in CTT with this method, we selected the mentioned times of segmental Sitzmark test (Metcalf protocol) for CTT evaluation, with attention to use lowest dose of radiation (One or at most two radiographs), and shortest time of examination (4 days or maximum 7 days) (10). After stopping medications, especially laxatives, patients ingested capsules daily on 3 consecutive days, and abdominal X-ray films were obtained on the 4^{th} day. The markers were single shape in the form of capsules containing 24 markers of knotted yarn of radiopaque barium, which were prepared by the pharmacist of our hospital. Barium yarns have the same density and consistency as food. If most markers remain and are not excreted (about 50 out of 72 markers), especially in the right and left colon, on the 4^{th} day radiograph, transit time was considered abnormal (delay or slow), and an additional abdominal X-ray would be taken on the 7^{th} day (11).

2-3. Measuring tools

To calculate the total and segmental transit times and to judge the approximate location of radioactive markers, the abdominal radiograph using bony landmarks was divided into 3 areas using the method proposed by Arhan et al. (12). The three areas were delimited on the antero-posterior abdominal radiograph, tracing a line joining the spinal processes of all the vertebrae to L5. Using L5 as center, lines were in turn traced to the left antero-superior iliac spine and to the right pelvic outlet, establishing areas corresponding to the right colon (cecum, ascending colon, proximal half of transverse colon), left colon (distal half of transverse colon, descending colon), and rectosigmoid junction. Total and segmental transit times were calculated by counting the number of retained markers in 3 colonic segments (right colon, left colon, and rectosigmoid junction) as a fraction of the total retained. A coefficient of 1.0 was used for day 4 calculations and 2.3 for day 7 calculations. Four patterns of CTT results have been reported: normal transit, colonic inertia, rectosigmoid retention and whole gut inertia (**Figure.1**). If markers were diffused throughout in colon, hypomotility or colon inertia was considered. If markers were gathered in the rectum or rectosigmoid, functional outlet delay was raised (**Figure.2**), and if retention of markers were observed in small bowl, whole gut inertia was considered to be raised (2). Reasonable transit time (compared to other studies) and no transit delay more than twice as other segments was considered as normal CTT. The normal upper limits for segmental transit time of right colon, left colon, rectosigmoid and total were considered 20, 20, 30, 60 hours, respectively. Abnormal transit time was defined as total CTT of more than 60. Total CTT between 60 –100 h was defined as delayed-transit and CTT more than 100 hours was considered slow transit (1, 13).

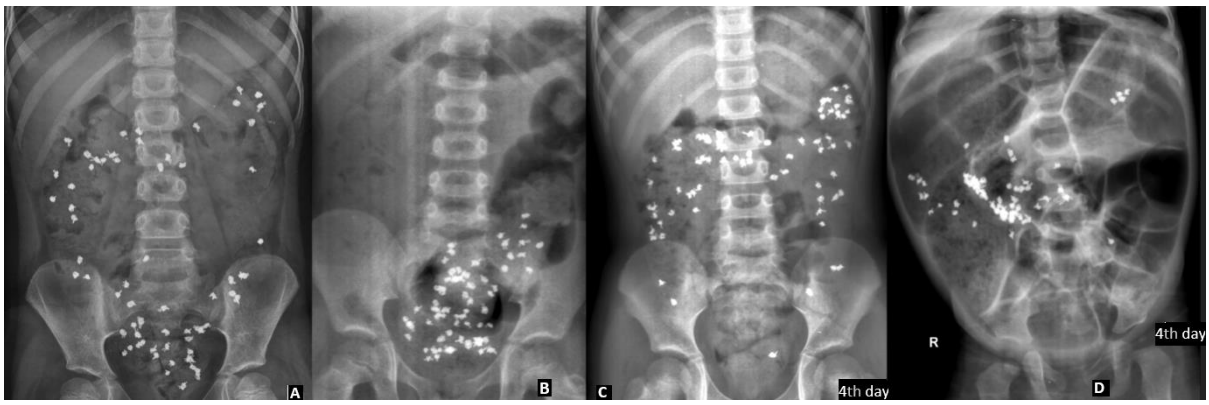

Fig.1: The 4th day radiographs of colon transit time from different patients; **A**) Normal pattern of CTT shows that most of markers have been defecated and there is non-segmental accumulation of markers. **B**) Abnormal rectosigmoid time shows accumulation of the markers in rectosigmoid area. **C**) Total colonic inertia is characterized by the accumulation of diffuse markers in the right and left intestines and their failure to reach the rectosigmoid area in 4th day. **D**) Only few markers have reached cecum in whole gut inertia cases.

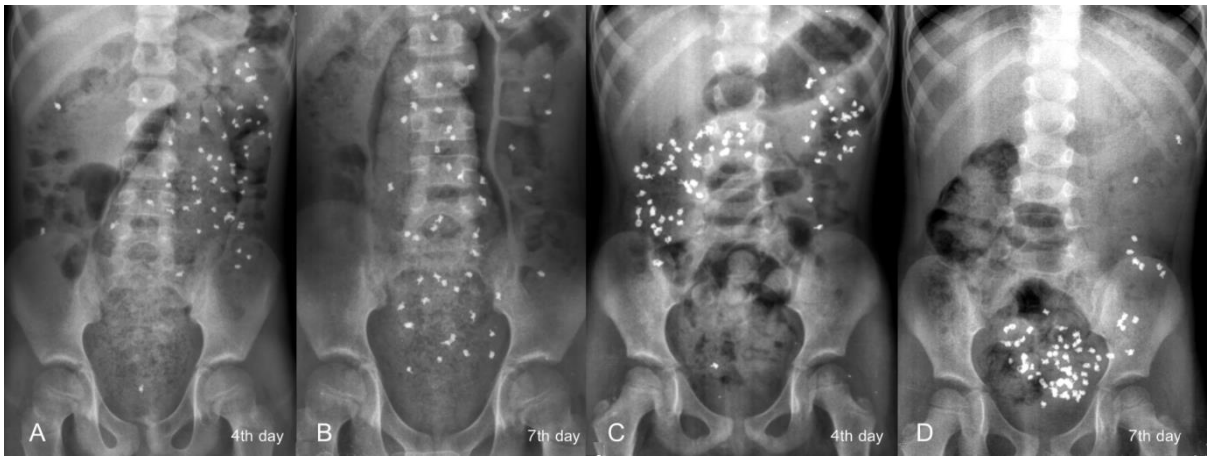

Fig.2: The 4th and 7th day's radiographs of colon transit time in two different patients. **A & B**) in left colon and rectosigmoid retention case, fecal and the markers retention in rectosigmoid is seen. **C & D**) in hypo-motility or colon inertia, the accumulation of markers is seen in the right and left intestines on 4th day that accumulation was transferred to the rectosigoid region on the 7th day.

2-4. Ethical consideration

This study was performed after being approved by the Ethics Committee and Institutional Review Board of Mashhad University of Medical Sciences, Mashhad, Iran (ID-code: IR.MUMS.REC.1394.631), and after obtaining informed consent from their parents.

2-5. Inclusion and exclusion criteria

Inclusion criteria were children over 2 years old with a history of chronic constipation for at least 6 months and having a normal diet. Exclusion criteria include: use of drugs that affect the digestive system during the study, history of abdominal surgery or other major surgery, any known underlying medical condition.

2-6. Data Analyses

Data were analyzed using SPSS software version 22.0 (SPSS Inc, Chicago, IL, USA). The level of significance was set at 0.05. Curves were used to determine the optimal upper limit transit time or cutoff value, sensitivity, specificity, and area under the curve (AUC) to differentiate normal transit time in comparison with abnormal transit time. The AUC test of 0.9-1 was considered as perfect diagnostic, 0.8-0.9 very good, 0.7-0.8 good, and it was sufficient when the AUC was 0.6-0.7, and insufficient when the AUC was 0.5 or less.

3- RESULTS

Colon transit time of 64 constipated children was analyzed; 28 boys and 36 girls, aged between 2-18 years with median of 8.6 years. The normal upper limits for segmental transit time of right colon, left colon, rectosigmoid and total were considered 20, 20, 30, 60 hours, respectively. There are significant differences between normal and abnormal groups with these cut-off ($p<0.001$) (**Figure.3**).

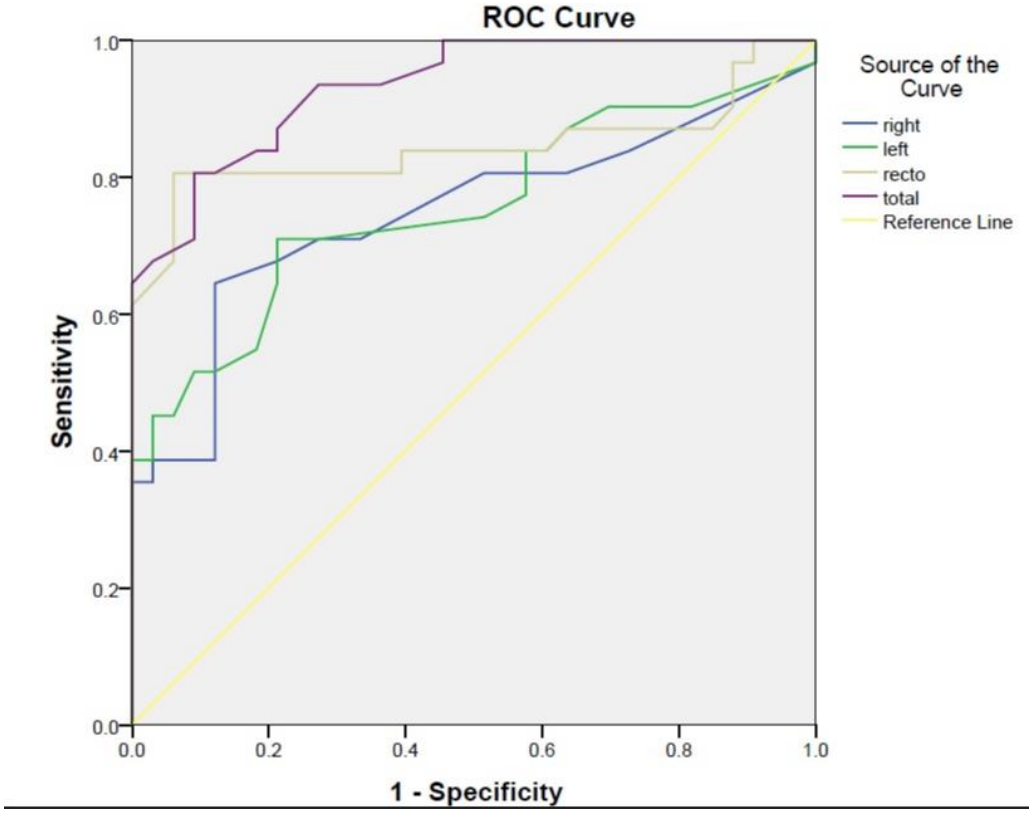

Fig.3: Comparison of ROC curves amongst transit times in segments and total of colon between normal and abnormal groups with proposed cut offs; the sensitivity, specificity, and area under the curve (AUC) of proposed cut-off of transit times to differentiate normal transit time in comparison with abnormal transit time.

The upper limit transit time with cutoff of 20h for right colon had specificity of 97% with AUC = 0.74, the cut-off of 20h for left colon had specificity of 97% with AUC = 0.75, the cutoff of 30h for rectosigmoid part of colon had specificity of 97.5% with AUC = 0.84, and the cutoff of 60h for right colon had specificity of 97% with AUC = 0.93. Based on this limit, thirty three cases (48.5%) had normal both segmental and total CTT. The mean and upper limits of transit time in the colon segments in these patients are shown in **Table.1**. There is no significant relation between age and sex and segmental transit time (P>0.05).

Table-1: The mean and upper limit segmental transit time in 33 patients with normal segmental and total CTT.

Colon Transit Time	Mean transit time ± SD (hour)	Upper limit transit time (hour)	P -value
Right colon transit time	6.6 (±5.2)	20	.000
Left colon transit time	8.8 (±5.7)	20	.001
Rectosigmoid transit time	21 (±9.7)	30	.000
Total	36.8 (±14)	60	.000

CTT: Colon transit time.

Of 43 patients with a normal total CTT, 10 (23%) had a prolonged segmental CTT. There was no statistically significant correlation between the abnormal segmental CTT and a normal total CTT ($p > 0.05$), but, there was a significant relationship between abnormal total CTT and abnormal segmental transit time in statistical evaluation ($p < 0.001$). Segmental transit time of the right colon was normal in 54 (84%) children (less than 20 hours) and was prolonged in 13 children (more than 20 hours), that included 11 cases with colonic inertia and two patients that had segmental prolonged transit time alone. Segmental transit time of left colon was normal in 47 (73%) children (less than 20 hours) and was prolonged in 16 (25%) children (more than 20 hours), that included 11 (17%) cases with colonic inertia and four patients with segmental prolonged transit time and another case with rectosigmoid abnormality. Segmental transit time of rectosigmoid was normal (less than 30 hours) in 39 (61%) constipated children and was prolonged in 29 (45%) including 11 (17%) cases of with colonic inertia and 18 (28%) other patients with rectosigmoid abnormality. Delayed-transit time (total CTT between 60 –100 h) was found in 7 patients; this group of patients had an abnormal prolonged segmental CTT, especially in the rectosigmoid region. The slow transit (total CTT > 100 hours) was seen in all cases (11) of colon inertia and 2 cases of rectosigmoid retention. In only one child with whole gut inertia, only few markers have reached cecum in 4^{th} and 7^{th} day radiographs (**Figure. 1 D**). Table 1 summarizes results of total and segmental CTT.

Table-2: Segmental and Total colon transit time in 68 constipated children and statistical relation between total colon transit time and segmental colon transit time.

Diagnosis	Mean (SD), hour	Number (%)	Total transit time	
			Normal	Abnormal
Normal segmental and total transit time	37(±14)	33 (48.5)	33 (48.5)	0
Rectosigmoid ±Left abnormality	53(±32)	18 (28)	14 (22)	4 (6.2)
Colon Inertia	140(±28)	11 (17)	0	11 (17)
Left segment abnormality	22(±20)	4 (6.2)	4 (6.2)	0
Right segment abnormality	17(±13)	2 (3)	2 (3)	0
Total	92(±45)	64 (100)	43 (67)	21 (33)

4- Discussion

The purpose of this study was to evaluate colon transit time and dysfunctional pattern in Iranian constipated children. According to the results of this study, the normal upper limits for right colon, left colon and rectosigmoid transit times were evaluated as 20, 20, and 30 hours, respectively. The normal upper limit for total CTT was 60 hours. The rectosigmoid retention (26.5%) and colon inertia (16%) were the most common abnormalities of CTT. Constipation is the most common gastrointestinal disorder, which may be caused by colonic transit dysfunction (13). CTT can provide very useful information about the colonic motor function, the

involved segment and severity of constipation. Different patterns of delayed or slow colonic transits have been described and specific therapies for different patterns have been successfully proposed (1). Four patterns of CTT results have been reported: normal transit, colonic inertia, rectosigmoid retention and whole gut inertia (**Figure.1**). If markers were diffused throughout in colon, hypo-motility or colon inertia was considered. If markers were gathered in the rectum or rectosigmoid, functional outlet delay was raised and if retention of markers were observed in small bowl, whole gut inertia was considered to be raised (2).

This research was performed to evaluate the times and patterns of colon transit time to diagnose and categorize of colon abnormalities in our area. Currently, using plastic radiopaque markers (Sitzmark studies) is a standard method which is widely practiced (2-4). The plastic radiopaque markers which have similar weight and density to foods are routinely used in colon transit studies, although catheters, wires and nasogastric tubes have been also used (2, 3, 6, 7, 14).

We used single shape markers of knotted yarn of radio-opaque barium which are very similar to regular food. Although several techniques have been described for CTT measurement, two are more conventional (10, 15). In this study, we used segmental Sitzmark test (Metcalf Protocol), considering results of a pilot study, and using low dose radiation and short time of examination. In this study, the normal upper limits of CTT were considered for the right colon, left colon, rectosigmoid, and total colon at 20, 20, 30, and 60 hours, respectively. As stated, the upper limit transit time with cutoff of 20h for right colon had specificity of 97% with AUC = 0.74, the cutoff of 20h for left colon had specificity of 97% with AUC = 0.75, the cutoff of 30h for rectosigmoid part of colon had specificity of 97.5% with AUC = 0.84, and the cutoff of 60h for right colon had specificity of 97% with AUC = 0.93. Currently, there are several researches for calculation of upper limits for normal segmental and total colonic transit times with different techniques (3, 4, 5, 7, 8) in different countries. These studies are summarized in **Table.3**.

Scintigraphic studies are excluded because reporting system for radio-opaque plastic markers and scintigraphic techniques are basically different and their comparison is difficult (15). Considering similarity of dietary regimen in Iranian patients and the times mentioned in the **Table.3**, the times in this study are close to results of Western researches. In Riahinezhad et al.'s study, in a group of Iranian patients with normosensetive constipation child, 12, 7, 21, and 54.2 h for left, right, rectosigmoid, and total CTTs, respectively calculated as cutoff value (16).

The mean colon transit time was reported 30-40 hours in most studies in Western countries and the upper normal limit was mentioned 70 hours (2). Although in some studies, abnormal cut-off is higher; right sided (colonic inertia) was considered as > 30h, rectosigmoid retention >40h, delayed colonic transit 60-100h and generalized slow colonic transit was considered as >100 h (13, 18). The mean CTT was reported 20-30 hours in healthy adults in Korea and China (2, 5), and 15.8 hours in healthy Indians population (6).

Table-3: Upper limits of normal segmental and total colonic transit times (hour) in current pediatrics studies.

Author, Year, References	Country	Method	Right colon TT	Left colon TT	Recto-sigmoid TT	Total TT
Arhan et al., 1981, (12)	France	Arhan et al.	18	20	34	62
Corraziari et al., 1985, (18)	Italy	Hinton et al.	-	-	-	32
Bautista et al., 1991,(19)	Spain	Metcalf et al.	18	18	19	50
Zaslavsky et al., 1998, (20)	Brazil	Metcalf et al.	14.5	23.5	37	56
Gutierrez et al., 2002, (21)	Spain	Metcalf et al.	19	19	30	46
Wagener et al., 2004, (15)	England	Abrahamsson et al.	-	-	41	84
Vande et al., 2013, (3)	Belgium	Abrahamsson et al.	29	31	65	86
Jung et al., 2003, (22)	Korea	Metcalf et al.	11.5	9.2	5.9	26.5
Kim et al., 2012, (4)	Korea	Metcalf et al.	7	10	10	24
Chan et al., 2004, (5)	China	Metcalf et al	16	31	32	62
Shava et al., 2018, (7)	India	Modified Metcalf's method	14	19	22	36
Our study	Iran	Metcalf et al.	20	20	30	60

Although delayed transit constipation is divided conventionally into three categories: right sided inertia, total colonic inertia and outlet dysfunction (2), we found four groups of right colon (1 case), left colon (4 cases), rectosigmoid (17 cases) and total inertia (11 cases). There was whole gut inertia in one of our patients. According to total CTT results of Benninga et al. study, constipated patients are also divided into two categories: normal- or delayed transit constipation (CTT < 100 h), and slow transit constipation (CTT > 100 h) (13). In this study, 30 constipated patients had normal transit (< 61 h), six had normal- or delayed-transit (between 62–100 h) and 27 cases had slow transit (total CTT > 100 hours). These results appear to resemble others studies (2, 3, 13). **Table.4** shows current researches in the field of pediatric radiology estimating segmental and total CTT with different techniques in constipated children (2, 13, 19, 21-23). As you see, in our study, about half of children with constipation had normal CTT. This is similar to the results from other researches except for the study conducted by Zaslavsky et al which has been done on a different patients' age group (adolescence versus children) (20). In addition, the rate of colonic inertia and other segmental abnormalities in our patients was also similar to others researches. Colonic inertia had maximum relationship with the whole CTT. All patients had total CTT more than 100 h. Colonic transit time pattern in Iranian constipated children is almost similar to other countries, and colonic inertia was detected in 17.5% of patients. The major limitation of our study was absence of a normal control group because healthy children do not cooperate with the performance of CTT and there are ethical limitations. Both segmental and total

normal CCT were found in half of our constipated patients. The normal upper limits for segmental transit time of right colon, left colon, rectosigmoid and total respectively 20, 20, 30, 60 hours had specificity of 97% with AUC = 0.74 until 0.93 to differentiate normal from abnormal transit time in northeast of Iran. These normal upper limits were slightly less than times found in Western countries. The rectosigmoid retention (22%) and colon inertia (17.2%) were the most common abnormalities of CTT.

Table-4: Current studies which show segmental and total CTT with different techniques in constipated children.

Authors, Year, References	Method	Abnormal Right colon	Abnormal Left colon	Abnormal Rectosigmoid	Abnormal total CCT	Normal total CTT
Benninga et al., 1996, (13)	Metcalf et al.	19%	17%	47%	25.5%	39%
Benninga et al., 2004, (23)	Metcalf et al.	-	-	-	-	56%
Gutiérrez et al., 2002, (21)	Abrahamsson et al.	13%	-	37%	-	50%
Zaslavsky et al., 1998, (20)	Metcalf et al.	60%	-	23%	10%	17%
de Lorijn et al., 2004, (1)	Metcalf et al.				22%	50%
Our study	Metcalf et al.	19%	25%	44%	22%	48%

5- CONCLUSION

The results showed that distraction technique had a good effect on the intensity of pain in children. Given the need for pain control and its effects on the course of treatment, further studies are needed to be done.

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7- CONFLICT OF INTEREST: None.

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