

**Original Article**

## Colon Transit Time Test in Korean Children with Chronic Functional Constipation

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**Purpose:** Each ethnic group has a unique life style, including diets. Life style affects bowel movement. The aim of this study is to describe the results of colon transit time (CTT) tests in Korean children who had chronic functional constipation based on highly refined data.

**Methods:** One hundred ninety (86 males) out of 415 children who performed a CTT test under the diagnosis of chronic constipation according to Rome III criteria at Konkuk University Medical Center from January 2006 through March 2015 were enrolled in this study. Two hundreds twenty-five children were excluded on the basis of CTT test result, defecation diary, and clinical setting. Shapiro-Wilk and Mann-Whitney U, and chi-square tests were used for statistical analysis.

**Results:** The median value and interquartile range (IQR) of CTT was 54 (37.5) hours in Encopresis group, and those in non-encopresis group was 40.2 (27.9) hours ( $p < 0.001$ ). The frequency of subtype between non-encopresis group and encopresis was statistically significant ( $p = 0.002$ ). The non-encopresis group ( $n = 154$ , 81.1%) was divided into normal transit subgroup ( $n = 84$ , 54.5%; median value and IQR of CTT = 26.4 [9.6] hours), outlet obstruction subgroup ( $n = 18$ , 11.7%; 62.4 [15.6] hours), and slow transit subgroup ( $n = 52$ , 33.8%; 54.6 [21.0] hours). The encopresis group ( $n = 36$ , 18.9%) was divided into normal transit subgroup ( $n = 8$ , 22.2%; median value and IQR of CTT = 32.4 [9.9] hours), outlet obstruction subgroup ( $n = 8$ , 22.2%; 67.8 [34.8] hours), and slow transit subgroup ( $n = 20$ , 55.6%; 59.4 [62.7] hours).

**Conclusion:** This study provided the basic pattern and value of the CTT test in Korean children with chronic constipation.

**Key Words:** Colon transit, Constipation, Encopresis, Defecation diary, Korea, Child

## INTRODUCTION

Each ethnic group on earth has its own life style, in-

cluding diets, which affects the bowel movements. Thus it is important to have ethnically unique data. It is well known that the normal colon transit time

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(CTT) value of the East Asian-adult is shorter than that of Western-adults [1,2]. There are several methods for colon transit function, including radio-opaque marker test, radio nuclide study, and wireless smart pill test. Although the radio-opaque marker test uses radiation, it is simple to perform and is cost effective. Therefore it is considered as the gold standard for colon transit function both in adults and children.

It is well known that constipation can be classified into 3 subtypes on the basis of the CTT test—normal transit type, outlet obstruction type, and slow transit type. These subtypes affect both the diagnostic process and the therapeutic options in adults [3].

Previous studies on CTT in children usually enrolled small numbers of children for normal CTT value or for CTT value in children with constipation [4-7]. Recently, a study on normal CTT which enrolled a large number of European children was published with proper statistical analysis [8].

Several pediatric studies were performed for CTT in Korea, however, the number of enrolled children is too small, or enrolled children were not homogeneous in terms of underlying disease [9-11].

This study describes the results of CTT tests in Korean children who had chronic functional constipation with or without encopresis, based on highly refined data collected from a defecation diary, medical records, and CTT test results, with proper statistical analysis.

## MATERIALS AND METHODS

Four hundreds nineteen children who met Rome III criteria for constipation [12,13] from January 2006 to March 2015 at Konkuk University Medical Center (Seoul, Korea) underwent CTT tests, and 415 children were enrolled in this study. Excluded were 4 children who failed the test.

### CTT test

After diagnosis, fecal disimpaction was done with bisacodyl (Dulcolax rectal suppository; Boehringer Ingelheim Korea, Seoul, Korea) or glycerin enema (Seong Gwang Pharmacy, Cheonan, Korea) + poly-

ethylene glycol 4000 (Forlax; Beaufour Ipsen Pharma, Paris, France) or lactulose syrup (Duphalc syrup; JW Pharmaceutical, Seoul, Korea) over 7-10 days. After about 1 month of maintenance medication with Forlax or lactulose syrup, CTT test was performed with capsules which contain 20 radio-opaque markers per capsule according to Metcalf protocol [14]. That is, capsules were ingested on 3 consecutive days and supine plain abdominal X-rays were taken on the 4th and 7th day. During the test, medications (including laxatives, anticholinergics, non-steroid anti-inflammatory drug, or antibiotics, etc.) or foods (banana, persimmon, etc.) which can affect intestinal motility were prohibited at least one day before the test. In case of acute illness (upper respiratory infection, acute gastroenteritis, etc.), the test was postponed. On the 4th and 7th day, retained markers were counted, and summed. In cases where the number of retained markers was less than 35, it was classified as a normal transit type. In cases where the number of retained markers was more than 36, it was classified as an abnormal transit type. An abnormal type was divided into an outlet obstruction subtype (markers retained mainly in rectosigmoid area and left colon area) and a slow transit subtype (markers retained mainly in right colon area or in right and left colon area). The definition of right, left colon area and rectosigmoid area on plain abdominal X-ray was the same as that described in the textbook of gastrointestinal disease [3].

### Defecation diary

A defecation diary was kept by the patients or guardians about frequency of bowel movement, consistency of stool, bleeding, soiling, and amount of fluid intake per day. A defecation diary was submitted per visit and was filed. On the basis of the defecation diary, the defecation pattern during CTT test was compared to that of the on medication period within one month in the same child. In cases where the defecation pattern during CTT test was worse than that of the on medication period, the CTT test result was accepted for analysis.

### Exclusion criteria

Two hundreds twenty-four children were excluded from 414 children on the basis of exclusion criteria. Finally 190 children were enrolled in this study. Some of the children overlapped during screening. Exclusion criteria were as follows: (1) the sum of retained radio-opaque markers on the 4th and 7th day was same or less than 10 on the CTT test ( $n=85$ ); (2) during the CTT test, there was acute ill-

ness or the pattern of defecation was better than that of the 'on medicine period' on the basis of the defecation diary ( $n=155$ ); (3) underlying diseases ( $n=9$ ); failure of the puborectalis muscle relax ( $n=4$ ), imperforated anus ( $n=1$ ), intracranial hemorrhage ( $n=1$ ), extreme obesity ( $n=1$ ), and epilepsy ( $n=2$ ); (4) older than 16 years ( $n=8$ ) (Fig. 1).

### Statistical analysis

For statistical analysis IBM SPSS Statistics ver. 21.0 (IBM Co, Armonk, NY, USA) was used. Shapiro-Wilk test and Mann-Whitney test were performed for values of the CTT test. For comparison of subtype frequency between non-encopresis group and encopresis group, a chi-square test was performed.  $p$ -value less than 0.05 was considered statistically significant.

## RESULTS

Twenty-six among 190 children were male. The median age was 5 years with interquartile range (IQR) of 4 year. In the non-encopresis group ( $n=154$ , 81.1%) there were 63 males with a median age of 5 years and IQR of 4 years. In the encopresis group ( $n=36$ , 18.9%), there were 22 males with a median age of 5 years and IQR of 2 years (Table 1).

As a whole, the median value of CTT was 43.8 hours with IQR 31.8 hours. The median value and IQR of CTT was 54 (37.5) hours in the encopresis

**Fig. 1.** Algorithm to select enrolled patients. Four hundreds fourteen children with constipation were screened on the basis of defecation diary, colon transit time test, and clinical status. Some of the patients were overlaped during screening. Finally, 190 children were enrolled in this study. \*Acute illness state or patient had better defecation during the colon transit time test than on medication. <sup>†</sup>Puborectalis failure ( $n=4$ ), imperforate anus ( $n=1$ ), intracranial hemorrhage ( $n=1$ ), anticonvulsant medication ( $n=2$ ), extreme obesity ( $n=1$ ).

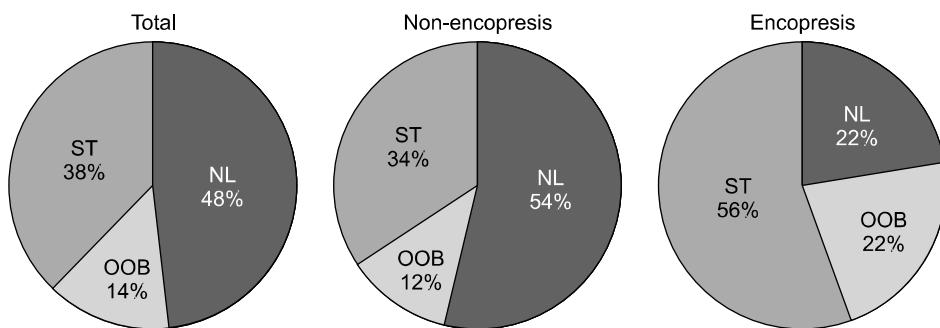
**Table 1.** Demographic Feature and the Result of Colon Transit Time (CTT) Test in Children with Chronic Functional Constipation

Variable	Total	Non-encopresis				Encopresis			
		NL CTT	ANL CTT		NL CTT	ANL CTT			
			OOB	ST		OOB	ST		
Children (n)	190		154 (81.1%)			36 (18.9%)			
		84 (54.5%)	18 (11.7%)		52 (33.8%)	8 (22.2%)	8 (22.2%)	20 (55.6%) <sup>†</sup>	
Age (yr)	5 (4)		5 (4)					5 (2) <sup>†</sup>	
Sex (male)	86 (45.0%)		63 (40.9%)					22 (61.1%)	
CTT time (hr)*	43.8 (31.8)		40.2 (27.9)					54 (37.5) <sup>§</sup>	
		26.4 (9.6%)	62.4 (15.6%)		54.6 (21.0%)	32.4 (9.9%)	67.8 (34.8%)	59.4 (62.7%)	

\*Values were expressed as median value (inter quartile range).

NL: normal, ANL: abnormal, OOB: outlet obstruction, ST: slow transit.

<sup>†</sup> $p=0.002$ , <sup>‡</sup> $p=0.525$ , <sup>§</sup> $p<0.001$ .



**Fig. 2.** The distribution of subtypes of colon transit time test. As a whole and in non-encopresis group, normal transit subgroup was the most frequent one. However, in encopresis group, slow transit subgroup was the most frequent one. The difference in frequency of subtype between non-encopresis group and encopresis was statistically significant ( $p=0.002$ ). NL: normal transit, OOB: outlet obstruction transit, ST: slow transit.

group, and was 40.2 (27.9) hours ( $p<0.001$ ) in the non-encopresis group. As a whole, normal transit was the most frequent (48%), slow transit (38%) next, and outlet obstruction (14%) the least frequent. The non-encopresis group ( $n=154$ , 81.1%) was divided into a normal transit subgroup ( $n=84$ , 54.5%; median value [IQR] of CTT, 26.4 [9.6] hours), an outlet obstruction subgroup ( $n=18$ , 11.7%; 62.4 [15.6] hours), and a slow transit subgroup ( $n=52$ , 33.8%; 54.6 [21.0] hours). The encopresis group ( $n=36$ , 18.9%) was divided into a normal transit subgroup ( $n=8$ , 22.2%; 32.4 [9.9] hours), an outlet obstruction subgroup ( $n=8$ , 22.2%; 67.8 [34.8] hours), and a slow transit subgroup ( $n=20$ , 55.6%; 59.4 [62.7] hours) (Table 1). The frequency of subtype between non-encopresis group and encopresis was statistically significant ( $p=0.002$ ) (Fig. 2).

## DISCUSSION

In this study, about 200 children were enrolled according to strict inclusion criteria on the basis of defecation diary, clinical information and result of CTT test. We think that with this process, the data became highly refined. The CTT test was performed after enough disimpaction, which made the result more accurate. In a previous study, CTT became shorter after disimpaction in the same children [15]. In addition, statistically, the data did not show normal distribution even though the number of enrolled

children was about 200. So, the results of this study were expressed as median values and IQR instead of average and standard deviation in previous studies. Recent pediatric study on CTT expressed the result in the same way as ours [8].

In this study, median value (IQR) was 26.4 (9.6) hours in normal transit group, which was somewhat shorter than previously known values [4-7,9,11]. We think that the upper normal value of CTT test in Korean children is 42 hours. Recent study showed that the values of CTT were about the same in adults and children older than 4 years irrespective of sex [16]. In Korean pediatric studies [9,11], and adult studies, upper limit of normal CTT was around 40 hours, even though enrolled patients were not homogeneous or statistics applied was not proper. According to the result of present study, the upper limit of normal CTT was less than 41 hours.

CTT test with radio-opaque makers were performed wide-spread in the world both in adults and children. In adults, normal CTT value of the East Asian adults is shorter than that of Western adults. The mean value of CTT is about 20-30 hours in Korean adults [1,2]. In pediatric studies, even though there was concern about reproducibility and wide variety in the results, the mean value was about 25-40 hours irrespective of race [4-7]. In one Korean study which enrolled only 10 control children, the mean value was expressed as  $30.7 \pm 10.5$  hours. However, those studies assumed normal distribution

and expressed the results as average and standard deviation, despite of small number of enrolled patients. In addition, those studies did not mention about disimpaction procedure before CTT test.

The difference in frequency of subtype was statistically significant between the non-soiling group and the soiling group ( $p=0.002$ ). Normal transit was the most frequent subtype in the non-soiling group, while, slow transit was the most frequent subtype in the soiling group. This result is consistent with the concept that the soiling stage is worse than the non-soiling stage, and this should be considered when planning treatment. The subtype frequency in non-soiling children was normal transit (50%), slow transit (13%) and outlet obstruction (37%), in a Western study [5]. In the present study, the subtype frequency in non-soiling children was normal transit (48%), slow transit (38%), and outlet obstruction (14%). In the non-soiling group, the subtype frequency was normal transit (54%), slow transit (34%), and outlet obstruction (12%). In the present study, the slow transit subtype is prominent and this may be due to data being collected at a tertiary center. In addition, some of the slow transit subtype children eventually were found to be in the outlet obstruction subgroup. So, further evaluations such as defecogram, are recommended for correct diagnosis, if possible. In one Korean study which enrolled children with abdominal pain, subgroups found were pelvic outlet obstruction (45%), hindgut dysfunction (24%), normal transit (14%), colonic inertia (13%), and slow transit (4%) [11].

In one Western study (soiling children 43/52, 82.7%) the subtype frequency was normal transit (40%), slow transit (29%), and outlet obstruction (21%) [15]. In another Western study (soiling children 90%), normal transit was 50% [17]. In the present study, the subtype frequencies in the soiling group were normal transit (22.2%), slow transit (55.6%), and outlet obstruction (22.2%). This result is worse than those of previous studies and suggests that fecal soiling implies an advanced stage of constipation. The median value of CTT was longer in the outlet obstruction subgroup than in the slow

transit subgroup (67.8 hours vs. 59.4 hours). This implies that genuine colonic inertia is very rare in children, even though slow transit is frequent, by definition according to the CTT test.

This study enrolled a large number of children, nevertheless the number in the soiling group was not enough. Further studies of this group are warranted. In 4 children who finally had failure to relax the puborectalis muscle on further study, CTTs were more than 100 hours and these children were excluded from analysis. Eighty-five children whose CTT was less than 12 hours were excluded from analysis as well. We cannot define clinical significance in this group.

It is well-known that the CTT test is important for diagnosis and treatment of constipation in adults. However, it is not clear in children. This study which describes the subtype of constipation in Korean children will provide a basis for further study. Recently, the concept that prolonged CTT might predict a poor prognosis was proposed [18]. Further studies are warranted on treatment and prognosis in terms of subtype of constipation and on the correlation between CTT and drug usage in child with functional constipation.

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