J Pediatr Res 2020;7(2):132-8
DOI: 10.4274/jpr.galenos.2019.33600

Original Article

The Effect of Pinna Position on Body Temperature Measurements Made with a Tympanic Membrane Thermometer in Pediatric Patients

Nilay Orkun, İsmet Eşer

Ege University Faculty of Nursing, Department of Fundamentals of Nursing, İzmir, Turkey

ABSTRACT

Aim: The aim of this study was to investigate the effect of pinna position on body temperature measurements made with a tympanic membrane thermometer in pediatric patients.

Materials and Methods: This study was conducted with a quasi-experimental design employing a pre-test and post-test. For analysis of the data, frequencies, percentages, means and standard deviations were calculated, and the significance of the difference between paired values was tested in order to investigate the effects of the auricle position on measurement values.

Results: The age of the patients included in the study ranged between 6 and 13 years, and the mean age was 10.25±1.83 years. The mean difference between measurements in the two different positions was 0.35°C. The measurements made in each position were represented in a Bland Altman plot. It was seen that the differences between the two positions were not distributed around zero, but instead showed a systematic distribution around 0.35°C. There was a significant relationship between the differences and the mean values. The difference between the mean durations of the measurements was found to be 1.07 seconds longer with pinna positioning than without. The discomfort levels of the patients during temperature measurement without pinna positioning and with pinna positioning ranged between 0-2 and 0-4 according to the facial expressions scale respectively. During temperature measurement with pinna positioning and without pinna positioning, patients felt no discomfort.

Conclusion: In measurements carried out using tympanic membrane thermometers in pediatric patients, positioning the auricle by pulling it downward posteriorly yielded more reliable and correct outcomes.

Keywords: Body temperature, pediatric patient, tympanic membrane thermometer, pinna position, nursing practice

Introduction

Body temperature measurement in pediatric patients is important for clinical evaluation and follow-up because body temperature is used as a guide in the diagnosis and treatment of diseases. Among the symptoms that determine the medical care requirements of a pediatric patient, fever is the most worrisome (1-4).

Body temperature measurement is the responsibility of nurses (5,6) and nurses should know how to measure body temperature and how to interpret these values (7-9). Acquiring professional knowledge and skills on body temperature measurement will be of benefit to nurses in terms of quality and efficacy of patient care.

Before they were banned, mercury thermometers were used for oral, rectal and axillary body temperature

Address for Correspondence
Nilay Orkun, Ege University Faculty of Nursing, Department of Fundamentals of Nursing, İzmir, Turkey
Phone: +90 505 343 36 08 E-mail: nilayorkunn@gmail.com ORCID: orcid.org/0000-0001-5591-5847
Received: *28.02.2019* **Accepted:** *30.07.2019*

measurement in pediatric patients (10-2). After the ban of mercury thermometers in 2009, different types of thermometers have started to be used for body temperature measurement (13).

In parallel with the technological developments, body temperature measurements may be done using invasive or non-invasive methods (10,14). For invasive body temperature measurements, readings are taken from the pulmonary artery, esophagus, rectum, and bladder (4,14,15). The non-invasive body temperature measurement devices are chemical thermometers, electronic thermometers and tympanic membrane thermometers (8,14).

An ideal method for measuring body temperature should be reliable, non-invasive, non-traumatic, culturally acceptable and hygienic (1,12,16). When measuring body temperature, the most suitable type of thermometer and the most appropriate anatomical region should be selected. In comparison to core temperature measurement methods, the accuracy and sensitivity of non-invasive body temperature measurement methods show variability. Today, studies on body temperature measurement have shown that various non-invasive measurement methods have superiority over invasive methods in terms of comfort, efficiency and infection control (8,17).

The tympanic membrane and the hypothalamus share the same blood supply originating from the carotid artery. Thus, the tympanic membrane reflects the core temperature (12,18-20). With its rich vascular structure, the ear canal is an accurate and accessible structure for measuring the core temperature. However, it is important to straighten the ear canal to ensure that the infrared sensor sees the tympanic membrane. Many studies have shown that tympanic membrane thermometers are accurate for measuring core temperature (1,16,21,22).

Many other studies have also emphasized that the clinical use of tympanic membrane thermometers should be supported (23-25). In a study conducted by the American Academy of Pediatrics and the American Academy of Family Physicians, it was found that 65% of pediatricians and 64% of family physicians were using tympanic membrane thermometers (26).

It is stated that a plastic protector cover should be used to straighten the external ear canal in order to make correct tympanic measurements. Placing the sensor tip in the ear canal and retracting the pinna will provide easy access to the tympanic membrane by straightening the external ear canal5. In children, the pinna should be gently pulled backwards and downwards (6,27).

Despite the importance of this theoretical knowledge, Turkish manuals for tympanic membrane thermometers do not contain any information on the necessity of pinna position adjustment (28). Although nursing students are taught to adjust the pinna position, it was observed that in clinical practice, graduated nurses did not carry out this practice when performing their nursing duties (29,30).

There is a difference between their theoretical information and their application in terms of the utilization of tympanic membrane thermometers. An ear canal that has a rich vascular structure is a true and accessible structure for the measurement of internal body temperature. As the tympanic membrane is close to the external cerebral artery, smoothing of the ear way is important for correct measurement (20).

In this practice, which is part of the responsibility of nurses, it is important for the nurse to apply the right technique to obtain accurate and reliable information. Although it is emphasized in the literature that the auricle should be positioned appropriately when the body temperature is measured with a tympanic membrane thermometer, (6) nurses usually neglect to perform nursing practice procedure due to their work overload (29,30). Thus, there are failures in clinical evaluations. In order to overcome these failures and to make accurate measurements, nurses should be taught to be able to use the correct technique during clinical evaluation by equipping them with the correct information on this subject (31).

The aim of this study is to investigate the effect of pinna position on body temperature measurements made with a tympanic membrane thermometer in pediatric patients.

Research questions

• Are the values measured when the auricle is correctly positioned different from those measurements taken when no positioning of the auricle is done?

• Is there a difference between the mean duration of measurements between the two positions?

• Is there a difference between the two positions in terms of the levels of discomfort felt by patients?

Materials and Methods

Study design

The study was conducted with a quasi-experimental design employing a pre-test and post-test.

Study setting and sample

The data were collected via "a Personal Information Form, a Facial Expression scale, a tympanic membrane

thermometer and a stop watch" by the researcher on 127 patients who were selected via convenience sampling at the healthy child outpatient clinic of a university hospital in the period of June- July 2016.

Intervention

Firstly, patients were selected via convenience sampling according to their order of arrival. Then, the patient's age and sex were recorded in the Personal Information Form.

Following this, measurements were carried out on the patients in the study firstly by not changing the position of the auricle. The duration was measured and the results were recorded in the data form. The levels of patient discomfort were evaluated by the "Facial Expression scale."

The measurement was then repeated after a minute, this time by changing the position of the auricle. The duration was measured for this position and the results were recorded in the data form. Again, the levels of patient discomfort were evaluated by the "Facial Expression scale."

Inclusion Criteria

The population of the study consisted of child patients who visited the healthy child outpatient clinic department as outpatients in the dates mentioned above. The study was limited to patients who were 6-13 years old, conscious, without communication issues, not diagnosed with otitis media and who did not have a fever. A study group of 127 patients who met these criteria and agreed to participate in the study was generated.

Sample Size Calculation

Case study was calculated with power analysis and calculated on 100% of the study. In the power statistical program, it was determined that 127 patients should be sampled according to body temperature measurement and an acceptable error size of 0.05 in groups.

Instruments

The "Personal Information Form" is a form that includes two questions based on socio-demographic characteristics (age, sex), The "Facial Expression scale" is used in evaluating the discomfort the patients feel based on auricle position change during the body temperature measurement, and it records the values for the duration of the body temperature measurement process and body temperature. This form was developed by the researchers. The score range of the "Facial Expression scale" is between 0 and 10. According to this scale, while "0" means "I do not feel discomforted", "10" means "I feel terribly discomforted". To measure body temperature in all the patients, only the Covidien brand tympanic membrane thermometer was used. Before the study was started, the Covidien brand tympanic membrane thermometer was calibrated and a pilot study was conducted with 15 people to assure the accuracy of the thermometer.

Ethical Considerations

Approval (number: 2016-177) was received for this study from the Scientific Ethics Board of Ege University, Faculty of Nursing. Written permission was taken from the Chief Physician of the Hospital of University, Faculty of Medicine to conduct the study in the healthy child outpatient clinic department of the hospital, while written consent was received from the parents of the child patients after information was provided to them about the purpose of the study.

Statistical Analysis

The statistical analysis of the data obtained in the study was carried out using the Statistical Package for the Social Sciences (SPSS) 21.0. For analysis of the data, frequencies, percentages, means and standard deviations were calculated, and the significance of the difference between paired values was tested in order to investigate the effects of auricle position on the measurement values. Additionally, systematic distributions of the data were examined with a Bland Altman plot which is used in repeated measurements based on positions. The results were interpreted in a 95% confidence interval and a level of significance of $p<0.05$.

Results

The age of the patients included in the study ranged between 6 and 13 years, and the mean age was 10.25±1.83 years. Of the patients participating in the study, 58.3% were male (Table I).

The mean body temperatures measured before and after positioning the pinna were 36.26±0.45°C and 36.61±0.45°C. The mean difference between the measurements made in two different positions was 0.35°C. This difference was found to be statistically significant (Table III) ($t=30.9$; $p<0.05$).

Table I. Descriptive characteristics of patients included in the study

Gender	**n**	**%**
Female	53	41.7
Male	74	58.3
Total	**127**	**100.0**
Mean age: 10.25±1.83 years		

In order to be able to analyze the reproducibility of the positions, the measurements made in each position were represented in a Bland Altman plot (Figure 1).

It was seen that the differences between the two positions were not distributed around zero, but instead showed a systematic distribution around 0.35. There was a significant relationship between the differences and the mean values. Thus, it was determined that the measurements made by positioning the pinna yield more significant results in terms of the usability of the positions (Figure 1).

According to Figure 1, the measurement results obtained by positioning the pinna were 0.35°C higher than the average (t=30.972 df=126, p<0.001). These results indicated that the differences between these measurements had no proportional bias on the mean values, and that according to the two techniques, the distribution was a random distribution. A similar result was obtained when the observation values were converted. Since in the Bland-Altman graph, a significant amount of points belonging to the differences between and means of the values of the two measurement methods were within the limits of agreement, it was concluded that there was no significant relationship between the differences between and means of these values (Correlation coefficient r=0.002873, p=0.9744).

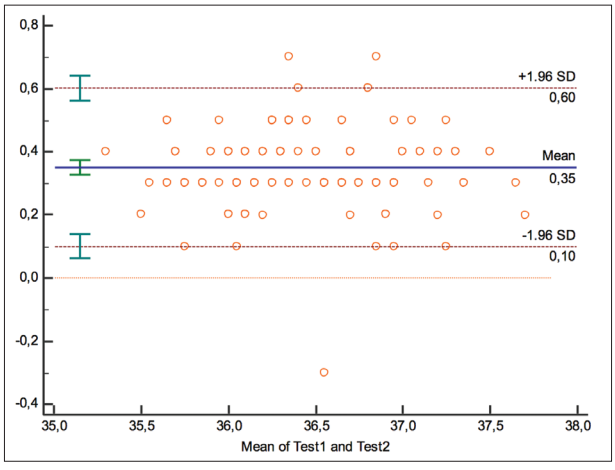
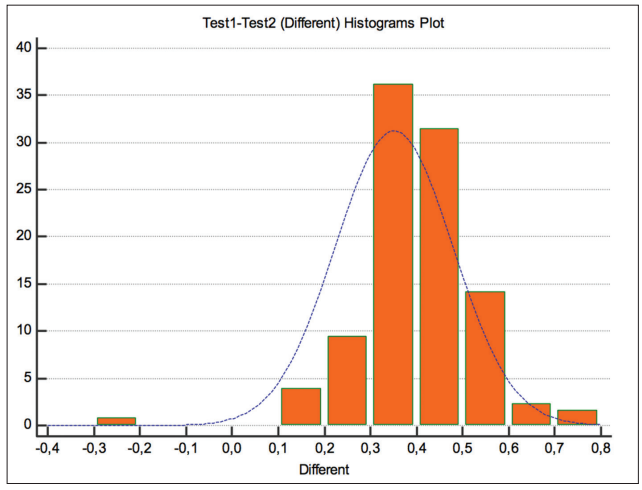


Figure 1. The Bland Altman plot for the measurements of body temperature in the two different pinna positions using a tympanic thermometer

Table II. Deming regression coefficients and confidence interval values

(Reference) / (Test) Test1 / Test2	Bias	95% Confidence Interval	Standard Deviation
Intercept	0.3277	-1.0584 - 1.7137	0.7004
Slope	1.0006	0.9623 - 1.0390	0.01936

In studies, in case the two variables yield erroneous measurements, the errors belonging to the two variables are minimized simultaneously with the Deming regression technique, which is one of the Type II regression methods used to minimize the function that will give the correct equation to best fit the observation values (Figure 2). Agreement analysis between the measurement results



(Test 1 changing the position of the auricle)
(Test 2 not changing the position of the auricle)

Figure 2. Deming regression technique or the measurements of body temperature in the two different pinna positions using a tympanic thermometer

Table III. Measurement results according to pinna position and durations of the measurements taken in the comparison of the two positions

	n	Mean (°C)		SD
With pinna positioning	127	36.61		0.45
Without pinna positioning	127	36.26		0.45
	Mean (°C)	**SD**	**t**	**p**
Difference between measurement results of two different pinna positions	0.35	0.22	30.9	0.000
	Mean		**SD**	
Duration of measurement with pinna positioning (seconds)	5.44		0.82	
Duration of measurement without pinna positioning (seconds)	4.36		0.83	
	Mean	**SD**	**t**	**p**
Difference between the durations of the measurements taken in the two different positions	1.07	0.08	13.71	0.000

SD: Standard deviation

Table IV. Discomfort levels caused during measurement in the two different positions		
Discomfort level without pinna positioning		
	n	**%**
FESS=0	97	76.4
FESS=2	30	23.6
Discomfort level with pinna positioning		
	n	**%**
FESS=0	86	67.7
FESS=2	29	22.8
FESS=4	12	9.5
Total	**127**	**100.0**
FESS: Facial expressions scale score		

obtained through the two different methods was performed by the Deming regression technique and the coefficients given in Table II were obtained.

The results obtained demonstrated that the intercept was computed as 0.3277. The confidence interval for this value includes the null value (value 0). Therefore, it is interpreted that there are no constant (statistically significant) differences between the two methods. The slope value was found to be 1.0006. The confidence interval for this value includes the value 1, which can be interpreted as that there is no proportional bias between the two methods Thus, it was found that there was no systematic and proportional bias between the measured values obtained with the two methods (Table II).

The mean duration of the operations performed with pinna positioning was 5.44 seconds (minimum (min): 3.7 sec; maximum (max): 7.3 sec) and the mean duration of the operations without pinna positioning was 4.36 sec (min: 2.7 sec; max: 7.6 sec) (Table III).

It was found that the difference between the mean durations of the measurements made with and without positioning the pinna (1.07±0.08 sec) was statistically significant ($t=13.71$, $p<0.05$).

The discomfort levels of the patients during temperature measurement without pinna positioning ranged between 0 and 2 according to the Facial Expressions scale ($\bar{x}=0.47\pm0.85$). Of these patients, 76.4% felt no discomfort, and 23.6% felt discomfort at a score of 2 (Table IV). The discomfort levels of the patients during temperature measurement with pinna positioning ranged between 0 and 4 according to the Facial Expressions scale ($\bar{x}=0.83\pm1.31$). Of these patients, 67.7% felt no discomfort, 22.8% felt discomfort at a score of 2, and 9.5% felt discomfort at a score of 4 (Table IV).

Discussion

The ages of the patients included in the study ranged between 6 and 13 years, and 58.3% of the patients were male. This result was obtained because of the characteristics of the patient group who applied to the healthy child outpatient clinic.

There are no studies in the literature examining the effect of the pinna position on tympanic temperature measurement. On the other hand, there are many studies on the reliability of tympanic thermometers. In the studies conducted by Giuliano et al. (9), Haugan et al. (21) and Purssell et al. (22) it was found that tympanic membrane thermometers were a reliable tool in body temperature measurement because they reflect the core temperature accurately.

Studies by Berksoy et al. (18), Yeoh et al. (32), Giuliano et al. (9), Haugan et al. (21) and Purssell et al. (22) found that tympanic membrane thermometers provide accurate values in body temperature measurement as they reflect internal body temperature.

Imani et al. (33) and Koçoğlu et al. (34) have also shown that tympanic membrane thermometers provide accurate results due to the rich blood flow of the tympanic membrane. In the study by Berksoy et al. (18) and El-Radhi and Petel (35) which compared the efficacies of different thermometers in pediatric patients, it was reported that the tympanic membrane thermometer yields reliable results even when the body temperature is changing rapidly, since tympanic membrane temperature reflects the pulmonary artery temperature. It was also found that measurements taken with a tympanic membrane thermometer yielded similar results to rectal thermometry, which is also a good reflector of the core temperature. In addition, tympanic thermometers gave more reliable results than axillary thermometers (18).

It is emphasized in the literature that the auricle should be positioned appropriately when body temperature is measured with a tympanic membrane thermometer (5,6,39). However, in Turkish guidelines about how body temperature is measured with a tympanic membrane thermometer, no information concerning the necessity of pinna position adjustment is mentioned (28). Therefore, this lack of information can lead to inaccurate measurements in the patients' treatment process.

In our study, the difference between the values measured in the two different positions was found to be 0.35°C (Table II). The American Society for Testing and Materials standard requires thermometers to be accurate within a maximum

error of 0.2°C between 35.8-37.0°C and 0.1°C between 37.0-39.0°C. If these standards are not met, the thermometer is not considered acceptable for use in clinical practice (36,37). Based on this knowledge, it was concluded that body temperature measurements made after positioning the pinna were found to be more reliable ($p<0.05$).

Many studies have reported that inaccurate measurements are usually related to errors in measurement techniques (38). In our study, according to the Bland Altman plot, the differences between the values measured with and without pinna positioning showed a systematic distribution around 0.35, and measurements taken with pinna positioning were found to be more reliable (Figure 1). Similarly, according to the literature, when the sensor tip of the tympanic membrane thermometer is placed in the ear canal and the pinna is pulled backward and downward, it allows the external ear canal to become straight. This allows the infrared sensor of the thermometer to directly meet the infrared rays, which is important for an accurate measurement (6,39). The results of our study are in accordance with this information.

It is thought that according to other nursing workload and patient safety research, (29,30) nurses do not correctly position the pinna while using tympanic membrane thermometers in order to reduce their workload and save time. The difference between the mean duration of operations with and without pinna positioning is 1.07±0.08 seconds. Although this difference is statistically significant, it is not a significant difference from a clinical point of view. In other words, pinna positioning will not burden nurses with additional workload.

Ensuring patient comfort during a procedure is an important responsibility for the nurse (6). In tympanic temperature measurements without pinna positioning, 76.4% of the patients did not feel any discomfort and the average discomfort was 0.47±0.85. In tympanic temperature measurements with pinna positioning, 67.7% of the patients did not feel any discomfort and the average discomfort was 0.83±1.31.

Conclusion

According to these results, in order to achieve accurate and reliable measurement values, the auricle should be positioned correctly, and the ear canal should be straightened. This method of body temperature measurement can be achieved through education and in-service training, as it is one of the jobs of nurses to measure body temperature. It was determined that nurses should position the pinna correctly in body temperature measurement procedures made with tympanic membrane thermometers. It was found that the measurements made by positioning the auricle did not require any extra application time and this application would not be an additional workload for the nurses. It was determined that body temperature measurement by placing auricle in the correct position did not cause discomfort in patients. Studies about the accuracy and reliability of measurements made with tympanic membrane thermometers should be repeated on different samples and the results should be shared.

Acknowledgments

The authors of this study would like to thank all the patients who participated in the research.

Ethics

Ethics Committee Approval: Approval (number: 2016-177) was received for this study from the Scientific Ethics Board of University, Faculty of Nursing.

Informed Consent: Written consent was received from the parents of the child patients after information was provided to them about the purpose of the study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: N.O., İ.E., Design: N.O., İ.E., Data Collection or Processing: N.O., Analysis or Interpretation: N.O., Literature Search: N.O., İ.E., Writing: N.O., İ.E.

Conflict of Interest: The authors have no conflicts of interest relevant to this article to disclose.

Financial Disclosure: The authors have no financial relationships relevant to this article to disclose.

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