Original Article

Effect of Auricular Position on Body Temperature Measurement with Tympanic Thermometers: A Quasi Experimental Study

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Abstract

Background: With the COVID-19 pandemic, body temperature measurement has begun to be widely used in the diagnosis of the coronavirus disease. When measuring body temperature, it is important to obtain the core temperature measurement. This study compared the results of body temperature obtained with the tympanic membrane thermometer—which is one of the methods that best reflect the body temperature—with or without positioning the auricle. **Aims:** The aim of this study was to investigate the effect of auricle position on body temperature measurements made with tympanic membrane thermometer in adult patients. **Materials and Methods:** A quasi-experimental design that employed a pre-test and a post-test was used in this study. A total of 143 patients who fit the inclusion criteria of the study were included in the sample. 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 measurement values. Statistical Package for the Social Sciences (SPSS) 22.0 was used in analyzing the data obtained in this study. **Results:** The difference between the values of measurement taken in these two separate positions was found to be 0.31 0C, and the Bland–Altman plot showed that the differences were distributed systematically around the value 0.31. **Conclusions:** It was found in the comparison of two positions that there was a significant difference between the tympanic thermometer measurements made by positioning the auricle and those without positioning.

Keywords: *Auricle position, body temperature, COVID-19, nursing practice, tympanic membrane thermometer*

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Introduction

One of the most common practices in clinical investigations is the measurement of a patient's body temperature.[1,2] Body temperature measurement has a significant place in the evaluation of clinical pictures and clinical monitoring.[3] Monitoring vital signs is one of the responsibilities of nurses,[1,4,5] and while doing this, a nurse should know how to carry out the measurement process, interpret the results and what the normal values are.[6]

This is why it is important for nurses to have accurate information on body temperature measurement and use the correct measurement techniques. Nowadays, in the emergency departments, temperature measurements are being taken using tympanic membrane thermometers[6,7] because these thermometers have many advantages; they measure the temperature fast (1–2 s), and they are easy to use. However, the accuracy of temperatures measured by infrared tympanic thermometers is a controversial issue among people interested in the subject.[6,8] The issue at hand is that various temperature measurement modalities yield different results.[1,3]

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High body temperature is an important symptom in the general diagnosis of the coronavirus disease during the COVID-19 pandemic. For this reason, using an accurate and reliable method is necessary to measure the body temperature in order to detect the disease. Methods that best reflect the core temperature should be used in measuring body temperature, as they measure the temperature of the artery branching from the external cerebral artery.[9] The study conducted by Hsiao *et al*. (2020)[10] concluded that in order to prevent the spread of COVID-19 epidemic, it is necessary to measure the body temperature at least twice with a method that accurately reflects the core body temperature.

Tympanic membrane thermometer is the ideal method in body temperature measurement.[6,8] Compared to the armpit or oral temperatures, the tympanic temperature reflects the core temperature more accurately, which was demonstrated by comparing the temperature measurements made in the pulmonary artery and esophagus.[11,12] The ear canal, a structure rich in vascularization, is readily accessible to measure internal body temperature.[13-15]

According to Haugan *et al*. (2013)[16] and Purssell, *et al*. (2009),[17] tympanic membrane thermometers were effective in establishing correct body measurement values because these thermometers present the internal body temperature. The study by Kocoglu *et al*. (2002)[18] and Imani, Rouzbahani, Goudarzi, Tarrahi, Soltani (2016)[14] showed that the tympanic membrane provides accurate measurements as it has high blood flow. It was showed that, even in cases where the body temperature changes rapidly, measurement with tympanic membrane thermometers provided accurate results as they reflect the temperature of the pulmonary artery.[3,5,19]

Studies by Berksoy *et al*. (2018),[19] Yeoh *et al*. (2017),[3] Giuliano *et al*. (2000),[7] and arterial blood flow to the tympanic membrane and hypothalamus occur through the carotid artery. This is why the tympanic membrane reflects the internal body temperature with very high precision.[3,14,16,20] The ear canal, with is a structure rich in vascularization, provides access for tools that measure internal body temperature with accurate results. Straightening of the ear canal is very important because the external cerebral artery branches from the carotid artery and the tympanic membrane is close to the external cerebral artery.[14] Several studies showed that tympanic membrane thermometers are accurate in measuring internal body temperature.[17,19]

The sensor tip of the thermometer is placed into the ear canal, and when the auricle is pulled, tympanic membrane is easily accessed.[1,3,21] The auricle should be pulled toward the back and up in adults, while it should be pulled toward the back and down in children.[13,15]

Despite this theoretical information, user manuals of tympanic membrane thermometers do not include any information on this auricle position change. Although nursing students were taught to change the position of the pinna during measurements with a tympanic membrane thermometer during their training, observations performed during clinical practices revealed that the graduate nurses did not change the position of the pinna while measuring the temperature with tympanic membrane thermometers.[22]

Body temperature measurement is an effective method used in SARS and COVID-19 screening. The most effective method for rapid screening of people is body temperature measurement during the COVID-19 epidemic, which spreads very rapidly. Tympanic membrane thermometers are widely used since they allow rapid measurement, they create no infection risk, and they reflect the core temperature efficiently.[9]

This study aimed to investigate the effect of auricle position on adult patients' body temperature values taken by using tympanic membrane thermometers. The hypothesis was "Position of the auricle during measurement of tympanic membrane temperature will affect the reading." The research question was "Does giving position to the Auricle affect the measurement values made with the tympanic thermometer?"

Subjects and Methods

Design

A quasi-experimental design that employed a pre-test and a post-test was used in this study.

The study participants

This cross-sectional study surveyed 143 patients from one of emergency departments in Turkey. Selection criteria for the patients were as follows: being 18 years old or older, having no problems in communication, volunteering to participate in the study, not having been diagnosed with otitis media, and not showing symptoms of fever. Since otitis media and fever could prove to be potential sources of bias, special care was given to these areas during the selection of participants.

Data collection

The data were collected by "Personal Information Form, Visual Comparison Scale, tympanic membrane thermometer and a stop watch" by the researcher on 143 patients. These patients were selected by using convenience sampling at the Emergency Services of a university hospital.

Data collection tolls

"Personal Information Form" includes three questions: age, sex, and presence of otitis media, and this form was developed by the researchers. "Tympanic membrane thermometer" was used during body temperature measurements. "Visual Comparison Scale," developed by the researchers, was used to evaluate the discomfort felt by the patients based on the changes in the auricle position, while their body temperatures were measured and the scale recorded the body temperature values the duration of the body temperature measurement process. The scores in "Visual Comparison Scale" range between 0 and 10.

According to this scale, while "0" means "I do not feel discomfort," "10" means "I feel terrible discomfort." "Stop watch" was used to record whether there is a difference between the measurement processes in terms of duration.

During the study, the Covidien brand tympanic membrane thermometer was used in taking the body temperatures of all patients. The Covidien brand tympanic membrane thermometer was calibrated before the study and a study with 15 individuals was conducted as a pilot study pilot to ensure that the thermometer provided accurate readings.

Intervention

Firstly, patients selected with convenience sampling. In the sampling method, the order of the patients' enrolment to the emergency room was used. Then, patient's age, sex, and presence of otitis media were recorded in the Personal Information Form.

This step was followed by taking patient measurements. At first, measurements were taken by keeping the position of the auricle intact. Stop watch was used during this procedure to measure the duration, and the results were recorded in the data form. "Visual Comparison Scale" was used to evaluate the level of discomfort experienced by the patients. A minute later, this step was repeated by changing the position of the auricle. Stop watch was used during this procedure where the position was changed to measure the duration, and the results for this position were recorded in the data form again. "Visual Comparison Scale" was used to evaluate the level of discomfort experienced by the patients. During the procedure, attention was paid to use the auricle on the same side for both treatments [Figure 1].

Sample size calculation

A pilot study was conducted with 15 adult patients so that the sample size could be determined. A power analysis was undertaken on the collected data, and the influence quantity was found to be d = 0.3645. It was found that 110 patients were required to participate in this study so that 99% power could be obtained at a level of $\alpha = 0.05$. Taking the possibility of data loss into consideration, a total of 143 participants were included in the study.

Ethical considerations

An application was made to the Scientific Ethics Board of University, Faculty of Nursing, and approval (number: 2015-106) was received for the study. Chief Physician of the Hospital of University, Faculty of Medicine, provided a written permission for conducting the study in the emergency department of the hospital. The patients, who were given information about the purpose and method of the study, provided written consents as well.

Analysis

Statistical Package for the Social Sciences (SPSS) 22.0 was used in analyzing the data obtained in this study. Frequencies, percentages, means, and standard deviations were used during data analysis, and the significance of the difference between paired values was tested to establish the effects of auricle position on measurement values. Bland–Altman plot used in repeated measurements based on positions was used to investigate the systematic distributions of the data. Confidence interval was found to be 95%, and the level of significance was accepted to be $P < 0.05$.

Results

The ages of the patients varied in the range of 18-85 years (=38.93 ± 15.28), 38.4% were in the range of 18-29 years, and 55.8% were female [Table 1].

The mean value taken from the measurements with the tympanic membrane thermometer was 36.99 ± 0.48 in measurements by positioning the auricle, and 36.68 ± 0.47 in measurements without positioning. The difference between the measurements obtained in two different positions was found as 0.31°C.

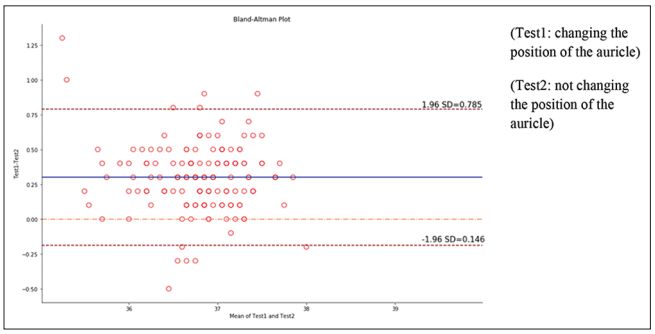

Figure 1: Research flow chart

Accordingly, it was found that the difference between the values in two different measurement positions was noteworthy [Table 2] (t = 15.12; $P < 0.05$).

While one of the researchers measured the temperature with the tympanic membrane thermometer, the other researcher measured the amount of time elapsed with a stopwatch and recorded it. The mean duration of measurement was 5.51 seconds (min: 3.5 max: 7.3) in the measurements made by positioning the auricle, and 4.42 seconds (min: 2.9 max: 7.6) in the measurements without positioning [Table 2]. Considering the difference between the durations of measurements made in two different positions (=1.08 ± 0.07), it was found that the difference was significant between the measurements with positioning and those without positioning (t = 15.16; $P < 0.05$).

Repeated Measurements Based on Positions Using a Bland–Altman Plot.

For the analysis of reproducibility of the positions, a Bland–Altman plot was obtained to show the repeated measurements of the positions [Figure 2].

In the comparison of measurement values obtained using a tympanic membrane thermometer with and without auricle positioning, it was seen that the differences in the plot of each position were not distributed systematically around 0, but they did around the value of 0.31, and there was a clear relationship between the differences and the mean. Accordingly, it was found based on usability of the results that the measurements made by positioning the auricle provided more significant results [Figure 2].

According to Figure 2, the measurement results obtained by positioning the pinna were 0.31 higher than the average (t = 14.749 df = 146, $P < 0.001$). The hypothesis "Position of the auricle during measurement of tympanic membrane temperature will affect the reading" was accepted. 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. Because in the Bland–Altman graph, the 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.

While the levels of discomfort felt by the patients during the body temperature measurement by positioning the auricle varied in the range of 0-8 (=1.13 ± 1.84), it was observed that 59.2% did not feel discomfort at all and 12.9% felt discomfort of level "1" [Table 3].

Table 1: Descriptive characteristics of patients included in the study

Gender	*n*	%
Female	79	55.8
Male	64	44.2
Total	143	100.0

Mean age: 38.93±15.28

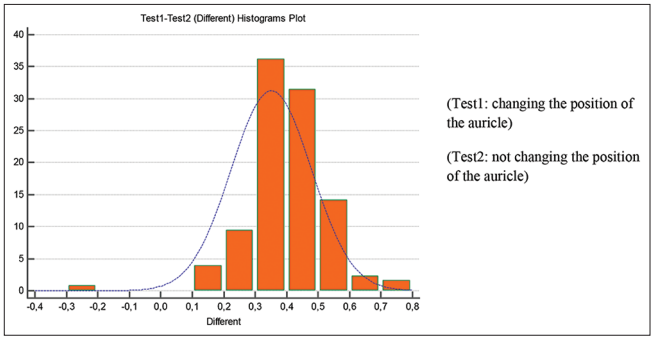

Figure 2: The Bland–Altman plot for the measurements of body temperature in the two different pinna positions using a tympanic thermometer

Table 2: Comparison of times measured in both positions

	Number	Mean (°C)		SD
With positioning of the auricle	143	36.99		0.48
Without positioning of the auricle	143	36.68		0.47
	Mean (°C)	**SD**	***t***	***P***
The difference between the measurement values in two different auricle positions	0.31	0.22	15.12	0.000
	Mean (seconds)			**SD**
With positioning of the auricle	5.51			0.81
Without positioning of the auricle	4.42			0.80
	Mean	**Standard Deviation**	***t***	***P***
The difference between the measurement durations in two different auricle positions	1.08	0.07	15.16	0.000

*$P<0.05$

Table 3: Discomfort levels caused during measurement in the giving auricle positions

	Discomfort level	
	n	%
VAS=0	86	59.2
VAS=1	18	12.9
VAS=2	13	9.5
VAS=3	10	6.8
Total	143	100.0

VAS: Visual comparison scale

Discussion

Body temperature measurement, which is significant in diagnosis and treatment of diseases, is one of the main indicators of life signs.[2,3,14,19,23]

During this process that is the responsibility of nurses, these healthcare professionals have to take the accurate measurement and know how they should interpret the results.

Correct and reliable usage of tympanic membrane thermometers, which are used frequently in emergency departments, is important in terms of intervening with hypothermia or hyperthermia on time and being able to assess the effectiveness of the treatment.[19,24,25]

While no previous studies exist in the literature investigating the effect of the auricle position on tympanic temperature measurement, various studies have examined the reliability of these thermometers. Giuliano *et al*.,[7] Haugan *et al*.,[16] and Purssell *et al*. report that tympanic membrane thermometers are highly reliable to take body temperature measurements due to their ability to accurately reflect core temperature.[17]

The literature underlines that the position of the auricle should be correct during temperature measurement by using tympanic membrane thermometers to get accurate results.[21,26,27]

The difference between the measurement values in the two different positions was found as 0.31°C.

Body temperature measurement is used to identify people who have the coronavirus and other disease. For this reason, it is important to measure temperature accurately with the tympanic membrane thermometer, which best reflects the core body temperature.[28]

According to the American Measurements and Calibration Standards, possible errors likely to occur in thermometers used in clinics would be 0.2°C in the interval of 35.8–37.0°, and 0.1°C in the interval of 37.0–39.0°. If this error rate is higher, such thermometers are not appropriate for clinical usage.[5,29,30] If these error rates are surpassed, the United States Customary Units Standardization stated that the values measured with thermometers did not reflect the true values and should not be used clinically.[12,29,30] The relevant literature showed that in measurements with tympanic membrane thermometers, pulling the auricle towards the back and up lead to straightening the external ear canal. So, we think this difference between the two positions indicates that measuring the body temperature by positioning the pinna is safer ($P < 0.05$). Similarly, in our study that was conducted in children, the difference between the two positions was found to be 0.35°C and there was a difference between the two positions. And our hypothesis supports that the position of the auricle does make a statistically significant difference in temperature measurement.

Inaccurate measurements have been reported in many studies to be caused by erroneous measurement techniques.[31] The current study found that the difference between the values measured in two separate positions of the auricle had a systematic distribution of 0.31 according to the Bland–Altman plot. According to this graph, it is possible to assess the availability of positions. The graph revealed that the measurements made by positioning the pinna yielded higher values than did the other position and the results obtained were more noteworthy.

Additionally, the relevant literature showed that in measurements with tympanic membrane thermometers, placing the sensor tip of the thermometer into the ear canal and pulling the auricle toward the back and up lead to straightening the external ear canal. This way, infrared rays reach the tympanic membrane, and this is required for accurate measurement.[4,5,29] Our results showed that the values measured by changing the position of the pinna were quite different.

According to researchers,[32,33] nurses do not pay enough attention to positioning of the auricle while using tympanic membrane thermometers due to workload related to other nursing tasks and lack of time. It was found that the difference between the mean durations of two procedures (where the auricle was positioned and not positioned) was 1.08 ± 0.07 seconds. While this difference was found statistically significant, it was not a clinically significant time interval. It was seen that measurements made by positioning the auricle would not create additional work load for nurses.

Providing comfort for the patient during procedures is important in the case of nurses, and it is their responsibility. It was found that 59.2% of the patients did not feel any discomfort by the body temperature measurement procedure carried out by positioning the

auricle. The mean level of discomfort of the individuals participating was found as 1.13 ± 1.84.

This article contributes the main finding that nurses should adjust the position of the pinna while measuring the temperature with tympanic membrane thermometers. Placing the sensor tip of the thermometer into the ear canal and pulling the auricle allows easy access to the tympanic membrane by straightening the external canal and it reflected the core temperature accurately.

Utilization of tympanic membrane thermometers in measurement of body temperature is highly important, and technique should be applied properly to obtain correct values in emergency department. In light of the results obtained in this study, it can be argued that the auricle should be positioned correctly and the ear canal should be straightened so that accurate and reliable measurement values can be obtained. This way, the tympanic membrane that receives blood via the external cerebral artery is placed straight ahead the infrared rays. This method of body temperature measurement should be included in the in-service training of nurses since measuring body temperature is one of most common, frequent, and crucial tasks of nurses.

The information in user manuals in Turkish about tympanic membrane thermometers should be updated to include the steps in the process of body temperature measurement, and nurses should use this method effectively. The information found in the literature on nursing practices of taking body measurements with tympanic membrane thermometers should be updated. This study reports that positioning the auricle to take body temperature does not require extra time so that the process does not increase the workload of the nurses. This study also reports that positioning the auricle for body temperature measurement does cause discomfort for patients. It is suggested to replicate the studies on the use of tympanic membrane thermometers for accurate and reliable measurements with different samples and to share the results with wider audiences.

Key messages

The tympanic membrane is one of the ideal points to measure body temperature because the external cerebral artery branches off the carotid artery and the tympanic membrane is close to the external cerebral artery.

Pulling the auricle allows easy access to the tympanic membrane by straightening the external canal.

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Conflicts of interest

There are no conflicts of interest.

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