DEVELOPMENT OF AN ANDROID-BASED ON RINNE TEST MODEL TO DETECT AIR – BONE GAPS IN HEARING LOSS PATIENTS

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Abstract

Background: Hearing loss is one of the problems of the health of the five senses. To do the initial screening, a garfu tala-based rinne test is used which is commonly used in health clinics. To test the accuracy and sensitivity of the android-based rinne test model through a mobile application.This research was designed with clinical prospective study methods. Implemented in Faisal Makassar Islamic General Hospital, LabuangBaji Makassar General Hospital, Makassar Hajj General Hospital and TK II Pelamonia Makassar Hospital and Bhayangkara Makassar Hospital.

Methods: 25 unilateral hearing loss patients (HL study group) have recruited successfully from five hospitals in Makassar department of otolaryngology, and 35 patients treated in the intermediate ward (IW) room at the same hospital and without hearing loss control (control group). Furthermore, both groups of registered Participants underwent a conventional 512 Hz tuning fork-based on Rinne test and an android-based on Rinne test using one open mobile phone with a vibrations application. Then the results have compared formal audiometry.

Results: The conventional Rinne Test and the Android-based on Rinne Test, both of them have the same level of accuracy, and sensitivity respectively (98%, 85%), while conventional tuning fork specifications is 90% and android-based is 93%. The android-based on Rinne test was able to show a difference in ABG sensitivity levels ≥25 dB, while the conventional on Rinne Test has shown lowering ABG sensitivity levels by 25dB at the same frequency (512 Hz). A moderately severe/severe sensorineural hearing loss was unable to be detected with 2 patients by the android-based on Rinne Test due to the inability to detect the vibrations

Conclusion: The android-based on Rinne test is an easy and practical alternative to simple tools with ABG detection capabilities ≥25 dB 512 Hz in clinical practice. The validity of this model as a whole requires further study.

Keywords: Hearing loss, Sensorineural hearing loss, Conductive hearing loss, Air – Bone Gap
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Introduction

In conditions where a person's on hearing process is still within normal limits, the air conduction (AC) is lower than bone delivery (BC). One of the instruments are used to measure and detect conductive hearing loss (CHL) is the Rinne test(Burkey et al., 1998). This test is used to compare air and bone conduction that is commonly done at the patient's bedside. Physical examination of the ear conventional

usually uses a vibrating tuning fork and is placed on the mastoid process until then the patient cannot feel or hear the sound due to a decrease in the AC threshold.The placement of the tuning fork is adjacent to the meatus acusticus externus (MAE) which is approximately 3-4 cm apart. To further confirm that Rinne's test is positive with an indication of CHL, the condition that must be met is when the patient listens to the vibration of the tuning fork which shows that the AC signal is better than BC(Sewall, 1909).Instead to determine the Negary Rinne test (BC<AC), where BC is better than AC for the progressive diagnosis of CHL cases. To determine the exact diagnosis of CHL from the results of the examination of the Rinne test refer to the frequency characteristics(Gelfand, 1977), recommended frequency specification is with a 512 Hz tuning fork(Kelly et al., 2018; Minor & Poe, 2010; Ram, 2016; Sataloff, 2015).

To determine the degree of chl differentiation in the clinical setting, the best instrument of choice is the Rinne test. Nevertheless the diagnosis of CHL is more easily established by doctors(Bickley & Szilagyi, 2012; Lasak et al., 2014; Michels et al., 2019; Wroblewska-Seniuk et al., 2018), although tuning forks are not available at their practice.

Telenursing/ telemedicine applications in the world of health are very necessary in today's digital era, covid-19 pandemic cases are increasingly popular, especially urban areas. Various applications in supporting the successful enforcement of otolaryngological diagnosis by doctors on patients include the use of android applications(Casale et al., 2018)..Such as the use of a tuning fork with a frequency of 512 Hz validated with an android vibrating app for the Weber test(Ungar et al., 2019).

The study is intended to compare conventional 512 Hz frequency tuning fork-based on Rinne testing and formal audiometry with android-based on Rinne testing.

Materials and methods

Study population

The research used a prospective control study that received approval from the health research ethics commission of the Makassar Health Polytechnic. By taking patients undergoing treatment at five hospitals in the city of Makassar, Department of otolaryngology, namely Faisal Makassar Islamic Hospital, LabuangBaji Makassar General Hospital, Makassar Hajj General Hospital and TK II Pelamonia Makassar Hospital and Bhayangkara Makassar Hospital.

Participants were patients who have been treated with CHL or a sensorineural hearing loss (SNHL), then followed a formal audiogram during the study. Meanwhile the comparison / control group is the client who is treated in the intermediate room ward without an autological pathology condition based on physical examination and medical history.

Materials

Using a conventional tuning fork of 512 Hz frequency (LN888 Medical Tala Fork) a Rinne test was performed. With an android-based brand Samsung Galaxy A30s23C3 open conducted Rinne test through the google play store vibrator application at no cost.

Method

Each participant undergoes a special physical examination by an otolaryngology doctor, where before the test is carried out, a past medical history is first studied. Once everything is complete then a conventional 512 Hz tuning fork-based on Rinne test and an android-based on Rinne test is performed. In the group study, testing was performed in the dominant ear while the control group was randomized.

The conventional Rinne test is performed by stomping the tuning fork on the side of the bed and then the tuning fork is placed in the mastoid processing position. The tuning fork is immediately moved on the meatus acusticus externus (MAE) in a perpendicular position of 3 – 4 cm, as soon as the patient no longer hears and sounds(Butskiy et al., 2016).The android-based on Rinne test is affixed to the bottom end of the android to the mastoid process which is further followed by the repositioning of the android on the lower end of the MAE.

Some of the conditions of the participants will be compared with past medical and surgical

history, namely demographic characteristics, ear pathology conditions, Rinne test results and formal audiograms. Whatever the findings of the Rinne test will not affect clinical decision-making.

Results and Discussion

More than 50% of respondents who have participated in the study met all inclusion criteria. The characteristics of the subject consisted of a study group and a control group 60 person. (average age 42 years, age range 19 – 67 years). Conditions of clinical pathology of CHL in subjects include serous otitis media, cholesteatoma, otosclerosis, and perforation of the tympanic membrane, and osteomas that clog the external auditory canal (15, 5, 3, 1 and 1). CHL and SNHL and HL became the main triggers with several symptoms of cholesteatoma, otosclerosis, and perforation of the tympanic membrane, osteoma that clogs the external auditory canal, sudden idiopathic hearing loss, vestibular schwannoma, and cisplatin-related otoxicity.

The various types of HL that have been identified Are mostly dominated by CHL the rest of the SNHL the underlying diagnosis is dominated by Cholesteatoma, ISSNHL, SOM (5 cases), followed by ISSNHL, and Osteoma (4 cases), then TM perforation (3 cases), Ototoxisity, and VS which are the least each (1 case). Disturbed right and left ear in a ratio of 8:17 (Table 1). The control group consisted of 35 patients (average age 42 years, range 19 – 27 years, 16 female, 19 male). There were no significant differences in sex or age range between groups (P = 0.70).

The accuracy rate of conformity between the android-based on Rinne test and the conventional Rinne test based on the 512 Hz tuning fork (98%). The conventional Rinne test is based on a 512 Hz tuning fork (+), but cannot detect vibrations emitted by androids when attached to a mastoid or meatus acusticus externa processus.

Fifteen patients from the study group (CHL) had an air-bone gap (ABG) frequency of 512 Hz measured by formal audiometry. ABG ≥ 25 dB with SNHL components at 512 Hz for 8 patients. Both groups underwent conventional and android-based on Rinne tests mostly showing positive results. The remaining seven CHL component patients, ABG 512 Hz ≤ 25 dB, with normal hearing thresholds obtained positive results for both the conventional tuning fork-based on Rinne test and the android-based on Rinne test.

In the study group, seven participants (SNHLs) had ABG no significant difference from 10 dB at a frequency of 512 Hz, with degrees of HLs (mild, moderately and severe) in the order of two, two and one). Both groups classified as mild HL produced positive Rinne tests on both methods. Both methods (tuning fork and android) failed to detect rinne ABG test results in the other three patients that are consisted of two patients with moderately severe category SNHL and one patient with severe category SNHL, Table 1.

Decreased ABGs in several cases of medical intervention including stapes surgery, Tympanostomy with ventilation tube insertion have been found in a study group of three patients. Both additional rinne test methods were performed that showed both positive results. There was one post-treatment patient who failed to close with an indication of cholesteatoma resection without hearing rehabilitation, obtaining perfect ABG, with a conventional Rinne test result and a negative android-based audiogram.

Meanwhile, in the ABGs of the control group, an audiogram was not carried out because no HL was found in the tracing of physical examination and medical history. The same results found in 31 patients on both Rinne's test methods both conventional and android-based showed positive results. There were five patients who failed to detect vibration, three of them by android and two by conventional (512 Hz). In the control group there was one person who failed to detect the android vibration but conventionally (tuning fork) Rinne's test was positive.

Table 1 General characteristics and test results of the study group

Gender	Age	Side affected	HL type	Diagnosis	ABG pre treatment					Conventional Rinne test	Android based Rinne test	ABG post treatment					Conventio-nalRinne test	Android based Rinne test
					250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz			250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz		
M	25	R	SNHL	Ototoxisity	15	20	15	20	15	+	+	4	4	5	3	3	+	+
F	39	L	SNHL	VS	5	0	0	0	0	No detection	No detection	NA	NA	NA	NA	NA	NA	NA
M	55	R	SNHL	ISSNHL	5	0	0	0	0	+	+	0	5	0	5	0	+	+
M	21	L	SNHL	ISSNHL	10	10	0	0	0	No detection	No detection	NA	NA	NA	NA	NA	NA	NA
F	52	L	SNHL	ISSNHL	30	20	15	20	10	+	+	NA	NA	NA	NA	NA	NA	NA
M	42	L	CHL	Cholesteatoma	30	20	35	35	30	-	-	0	0	0	5	5	+	+
M	28	L	CHL	TM perforation	15	20	15	15	15	+	+	0	0	0	5	5	+	+
M	27	L	CHL	SOM	30	35	35	25	20	-	-	0	0	0	5	5	+	+
F	28	L	CHL	SOM	10	15	15	20	25	+	+	0	0	0	5	5	+	+
M	32	R	CHL	SOM	25	15	20	30	35	-	-	0	0	0	5	5	+	+
F	36	L	CHL	SOM	35	40	25	25	25	-	-	0	0	0	5	5	+	+
M	10	R	CHL	SOM	35	35	35	35	30	-	-	0	5	5	0	0	+	+

M	18	L	CHL	TM perforation	40	40	35	30	30	+	+	0	0	0	5	5	+	+
M	27	R	CHL	Osteoma	20	15	15	30	35	-	-	5	5	0	0	0	+	+
M	32	L	CHL	Cholesteatoma	35	40	35	40	25	-	-	0	0	0	0	0	-	-
F	55	R	CHL	Osteoma	35	30	35	35	40	-	-	0	5	0	5	0	+	+
F	46	L	CHL	Cholesteatoma	30	35	35	35	40	-	-	0	5	0	0	5	+	+
F	36	R	CHL	Osteoma	30	35	35	35	40	-	-	5	10	5	0	0	+	+
M	46	L	CHL	Cholesteatoma	35	40	35	35	35	-	-	5	5	0	0	0	+	+
M	49	R	CHL	Osteoma	40	35	40	40	35	-	-	40	50	45	40	45	-	-
M	45	L	SNHL	ISSNHL	10	15	20	15	15	+	+	0	5	0	5	0	+	+
F	47	L	SNHL	ISSNHL	35	20	25	25	25	+	+	0	5	0	5	0	+	+
M	50	L	CHL	Cholesteatoma	40	30	35	35	30	-	-	0	5	0	5	0	+	+
54	42	L	CHL	TM perforation	25	30	25	25	25	+	+	0	5	0	5	0	+	+
M	26	L	CHL	SOM	30	35	35	35	20	-	-	0	5	0	5	0	+	+

HL, hearing loss, CHL, conductive hearing loss, SNHL, sensorineural hearing loss, L, left, R, right, TM, tympani membrane, ISSNHL, idiopathic sudden sensorineural hearing loss, VS, vestibular schwannoma, ABG, air-bone gap, SOM, serous otitis media, NA not available

Table 2 General characteristics and test results of the control group

Gender	Age	Side tested	ConvetionalRinne test	Android based Rinne test
F	33		+	+
M	48		+	+
M	58		+	+
M	40		+	+
M	47		+	+
M	20		+	+
M	31		+	+
F	21		+	+
F	19		+	+
F	67		No detection	No detection
M	20		+	+
M	29		+	+
M	51		+	+
M	58		+	+
F	47		+	+
M	53		+	+
M	55		+	+
F	33		+	+
F	54		+	+
M	64		No detection	No detection
F	58		+	+
M	41		+	+
F	30		+	+
F	32		+	+
F	36		+	+
M	32		No detection	No detection
F	39		+	+
M	18		+	+
F	33		+	+
F	69		+	+
M	47		+	+
M	53		+	+
F	55		+	+
F	33		+	+
M	54		No detection	No detection

The Covid-19 pandemic has changed the strategy of the Health / nursing service approach in the form of telenursing / telemedicine service package applications to facilitate and bring closer access to patient services with primary health services. To minimize contact and prevent the risk of exposure to Covid-19, the telenursing/

telemedicine service innovation program is the main choice for some patients and service providers, especially related to anamnese, past medical history and limited physical examinations. On the other hand, audiometric services are not yet fully available, for which an alternative diagnosis program is needed as the best solution.

The Rinne test was invented a century ago by Adolf Rinne of Göttingen, Germany precisely in 1885(Sewall, 1909). It has not been until 40 years later that this instrument began to be used in healthcare practice and since then it has been generally included in an important part of physical examination especially patients suspected of having HLs(Ng & Jackler, 1993). The use of this tool can be an initial solution for otolaryngologists to detect CHL in a number of patients who have hearing loss.

The sensitivity level and specifications of the tuning fork are 512 Hz – 16 – 87% and 55 – 100% respectively on the Rinne test with CHL(Bayoumy & de Ru, 2020; Hibscher et al., 2021; Kelly et al., 2018).Various parameters are used as guideline in measuring rinne test performance standards, including objects that produce vibration on the tuning fork(Samuel & Eitelberg, 1989), the tuning fork material(MacKechnie et al., 2013), the tuning fork placement technique in the mastoid process(Butskiy et al., 2016). Because the guidelines are different, the accuracy of the resulting results is different(Bansal et al., 2022; Browning & Swan, 1988).

The use of tuning forks for Rinne and Weber's test purposes were a simple tool that was easy and practical to use to distinguish CHL and SNHL before the android-based on pure tone audiometry was introduced. The latter instrument was later designated as the gold standard for detecting various types of HL(Butskiy & Nunez, 2018).Currently, the android-based on Weber Test has successfully tested validity and reliability and the results are declared valid(Ungar et al., 2019).

Another advantage of the android-based on Rinne Test is that it is able to shorten the duration of an idiopathic sudden SNHL for the benefit of establishing a diagnosis. Our results show that the android-based on Rinne Test is the best choice for diagnosing CHL with etiological variations.

The repetition of the android-based on Rinne test examination after the CHL case was handled became valid and was selected as the primary diagnostic tool by the doctors at their practice. In addition, in general between conventional tests and audiometry the accuracy level is comparable, but the android version became the top choice by doctors in later studies.

This study has several limitations, namely the number of samples is lacking, the model used for research purposes only relies on one android model, android models that differ from one another, especially the frequency of vibrations produced. Another limitation is that testing is carried out by health workers (doctors and nurses) rather than carried out by patients.

Conclusion

The android-based on Rinne test is an easy, practical alternative to simple tools with comparable accuracy to conventional Rinne tests. The android model has been tested for validity and declared valid for use in telemedicine and telenursing physical examinations.

Author contributions

II : Article writing and data search,
BK : Research construction
MB : Data analysis,
NN : Proof reading
SK : Library source search
SM : Study design and literature review collection

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Every author contributes to the Article Processing Charge

Data availability

The availability of supporting data that supports the research is prepared by the author himself and the data is not published to the public because it relates to patient secrets and professional ethics

Conflict of interest None

Ethical approval

This research has received approval from the Health Research Ethics Commission of the Makassar Health Polytechnic which is one of the institutions authorized to issue research ethics recommendations.

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