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Development of an Ergonomically – Designed Violin Chinrest Using Additive Manufacturing

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Abstract. A violin chinrest is used to ease the pain and prevent injuries of violinists. However, some of them experienced discomfort using normal chinrest. It causes injuries, irritations, and pains that affect the performance of violinists. In that problem, the researcher works toward a goal of not curing the problem but instead avoiding pain, injuries, and discomfort when playing it. A convenience sampling method was used in gathering anthropometric data. The study is limited to the ergonomically designed chin rest itself, which will only be installed at the standard violin size with a length of 60 cm. The designed chinrest is fitted only for the violinists of Jose De Piro Kabataan Orkestra. Three ergonomically designed violin chinrests were produced, which are: side-mounted, semi-centered, and fully centered. The researchers used a paired-samples t-test to compare the means in the results of testing between the normal chinrest and the ergonomically designed chinrest using additive manufacturing. The study concludes that the ergonomically designed violin chinrests using additive manufacturing are light-weight, less expensive, more comfortable to use, and lessen the pain of the violinists based on the overall mean compared to the normal violin chinrest in terms of side-mounted, semi-centered, and centered chinrest.

Keywords: Additive Manufacturing, Chinrest, Ergonomics, Violin

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1. Introduction

As a country of many indigenous cultures in the Philippines, many precolonial rituals are practiced even after four centuries of Western occupation. In addition to strong oral and written traditions, modern

Filipino music has helped maintain these indigenous societies. Filipino composers of the second half of the 20th century and beyond were able to incorporate vernacular musical concepts into Western compositional languages, producing a new style of contemporary music unique to the Philippines. This development not only educates townspeople about native music Filipinos but also the entire Western music community. Today, the violin works of contemporary Filipino composers are largely unrecognized [1].

The medieval fiddle, the Italian lira da braccio of the 16th century, and the rebec of the Renaissance all served as inspiration for the violin's development as a bowed stringed musical instrument. In terms of musical instruments, the violin is the most popular and widely used instrument in the world [1]. The violin, also named fiddle, is a type of wooden chordophone in the violin family. The majority of violins feature a hollow wooden body. It is the family's smallest and thus highest-pitched instrument in common usage. A chinrest is a tool that has been specially designed to assist the jaw of the player or the chin posture while playing a violin. It is connected to the body of the instrument besides the tailpiece. A variety of materials are used to construct chinrests such as plastic or wood. The chinrest is necessary for instrument support; however, it was only invented in the 1820s. German composer Louis Spohr, who invented the chinrest, contributed to the development of current violin performing techniques. The tailpiece was supposedly damaged by Spohrs aggressive playing style, so he put a little block to the bout to preserve it. This was formerly viewed as a response to the increased complexity of the repertoire, which necessitated the use of more sophisticated free left-hand techniques. The instrument quickly acquired recognition among the majority of violists and violinists due to the support of well-known violinists of the time, such as Pierre Baillot and Giovanni Battista Viotti, and is today considered an integral element of both instruments' repertoires. With one or two metal clamps that loop over the instrument's rear edge, the chinrest is attached. To keep the chin rest in place, a small clamping force is applied by turnbuckles or machine screws. Hill-style clamps are usually used in pairs, and each clamp has its own foot and screw. In most cases, a metal bar that fits around the back edge of the instrument is used instead. Cork, leather, or felt is commonly used to cushion the clamps and chinrest which have direct contact with the instrument [2].

Chinrests are available at a local violin shop that also offers violin accessories. These are available in over a hundred various patterns to accommodate a range of structures of the jaw, and also a range of performing habits and positions. It is common for violinists and violists to experience soreness and discomfort from an improperly fitted chinrest, as well as a head tilted too far to the left, resulting in an unnaturally right-angled appearance.

When a chinrest is adjusted properly, the distance between the jaw and the chinrest's top should be around half an inch. The player should keep his or her gaze straightforward. With the help of a cork riser, the height may be altered. A chinrest that stretches above the tailpiece may be preferred for players with limited shoulder joint flexibility. Through the collarbone, a correctly fitted chinrest transmits pressure first from the arm to the spine, the body's natural support system. This frees up the left arm for vibrato and fingerboard shifting [2].

There are many different types of instruments that need to be played in a non-symmetrical manner. When it comes to damage, a variety of things might come into play. Some experiences of the violinist different problems and injuries using the existing chin rest. In a study conducted by Caero and Cohen, there is a case report that a twenty-six-year-old had a skin lesion on her left submandibular and supraclavicular neck was the reason she came in. When the subject used the chinrest, her left submandibular lesion felt particularly thick and indurated on occasion [3].

Additive Manufacturing (AM) is a general term that refers to technologies in which a product is constructed by layering materials on top of one another. These processes are fundamentally dissimilar to subtractive or consolidation processes. Rapid prototyping is the most frequently used word to refer to additive fabrication. AM, widely known as 3D Printing, is improving the way things are designed, manufactured, and serviced. Today, 3D printing is widely used in a wide range of industries, including those involving electronics, robotics, engineering, architecture, transportation, manufacturing, agriculture, medical, aircraft, desalination, education, satellites, oil & gas, and many more [4]–[17]. There are many various ways to produce an ergonomically designed violin chinrest. AM is one of the most efficient and effective ways of doing it. It is the method of assembling materials to create 3D objects from 3D model data. A digital design tool can be used and it has industry-leading performance and flexibility, all without the need for specialized tools or equipment. As a method of producing the ergonomically designed chinrest, AM has a high customization feature that enables the researcher to produce the design that would ergonomically fit to the end-user. Unlike the commercially available chinrest, the ergonomically designed chinrest is more affordable, lightweight, and more improved in its design parameters [4].

This study will focus on designing and developing an ergonomic violin chinrest utilizing additive manufacturing technology to avoid injuries and fractures caused by a standard or commercially available chinrest. The research study is limited to the ergonomically designed chin rest itself and it will be installed to the 4/4 standard violin size with a length of 60 cm with 40 mm thickness. Also, the violin should rest on the collarbone and should be supported by the left hand and by the left shoulder. The designed chinrest is custom-fitted for the 30 violinists in Jose De Piro Kabataan Orkestra, both male and female. The study aims to produce 3 ergonomically designed chinrests which are, side-mounted, semi-centered and fully-centered.

2. Materials and Methods

2.1 Design Requirements

In product development, process management, and design engineering, TRIZ is commonly utilized [18]. In this study, the set of contradictions to solve is the object-generated harmful factors and shape as shown in Figure 1. The TRIZ matrix proposes the following principles to solve this contradiction: the transformation of the physical and chemical states of an object, parameter change, and changing properties. It will interest you to know that every object in existence undergoes a state change. Parameters can be changed so that the function can be used properly. Changing properties, replace wood with hypoallergenic plastic filament as a material.

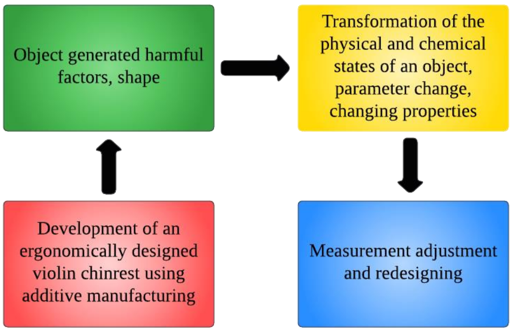


Figure 1. TRIZ Methodology for Violin Chinrest

In order to create the ergonomic violin chinrest design, it is important to identify first the design parameters and factors that affect the violin chinrest. The researchers use the study of Richard Ward 2020 "How to choose the right chinrest for violin/viola" [19]. It depends on a variety of things, including the playing posture, the body, and where they want to place the chin rest. All of these aspects must come together to satisfy your musical demands and personal comfort, and this guide hopes to assist you in determining what is best. Most violinists and violists, however, must find the best fit for their individual anatomy and playing style. Because head anatomy varies greatly, particularly the jaw, chin, and neck, one size does not fit all when it comes to chin rests. In measuring the said head anatomy, particularly the Jaw, Chin, and Neck which greatly affects the use of the violin chinrest, the usage of caliper (manual and digital) was utilized as well as the usage of tape measure when needed. Also, to avoid confusion, the only measure is the left-sided violinist player since is the most dominant side and common, as shown in Table 1.

Table 1. Measurement Guide for the Design

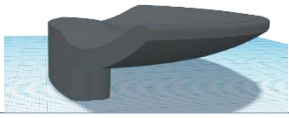
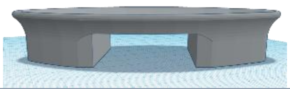
Jaw Length Measurement (mm)	**Chin Width Measurement (mm)**	**Neck Height Measurement (mm)**
		

2.2 Materials and Fabrication Procedures

The material used in this study is PLA or polylactic acid, it is a thermoplastic monomer produced by renewable natural sources such as starch granules or sugar cane. It is biodegradable, is considered the safest 3D printing material, and can reduce allergy issues [20].

Autodesk Inventor software and Tinker CAD were used in creating the 3D models after a careful examination of the chinrest designs. The 3D models were then exported to an STL file format in preparation for the FDM 3D printer software to determine the printing time, filament quantity, infill density, infill pattern, and sizes. Center-mounted, semi-centered, and side-mounted chinrest designs were developed as a result of these considerations as shown in Table 2.

Table 2: Types of Chinrest Final Designs and Specifications

Side-Mounted Chinrest		**Dimension:** **100mm x 70mm x 30mm** **Width: 70mm** **Height: 35mm** **Length: 100mm**
Semi-Centered Chinrest		
Centered Chinrest		

The side-mounted chinrest features a deeper and larger cup than the chinrest next to the tailpiece. You should aspire to build a body that is not just light but also incredibly strong. It is composed of PLA, is practically unbreakable, and will not create any form of reaction. Furthermore, it provides a better grip and a more natural playing position.

Simple oval-shaped chin rest with a higher ridge, deeper cup, and sharply curved design to give stability and sit securely next to the tailpiece of the violin. This semi-centered mounted chinrest is made of PLA for its strength and lightweight, making it more ergonomically.

The center-mounted chinrest is flatter and has a much larger cup; the depth is correct, the footing is long, and it matches the tailpiece of the violin, making it more centered across the instrument. This final design improves the tonality. This is also lifted to clear the tailpiece and make the design more ergonomically.

Post-processing was done after printing the ergonomic chinrest. Procedures such as sanding and acetone vapor polishing were used to smoothen the surface of the 3D-printed ergonomically designed chinrest.

3. Results and Discussion

A t-test is the best tool that can be used in comparing the means of two groups. Also, it is often used in hypothesis testing to find out if a procedure or treatment really has an effect on the population of interest.

Using a dependent t-test or paired-samples t-test, the means were compared in the results of testing between the normal chinrest and the ergonomically designed chinrest using additive manufacturing. Where the null hypotheses states that, there is no significant difference between normal chinrest and ergonomically design chinrest using additive manufacturing. While the alternative hypotheses states, there is a significant difference between normal chinrest and ergonomically design chinrest using additive manufacturing.

Table 3: t-test comparison of the 3D-printed Violin Chinrest and Normal Chinrest in terms of the Characteristics

3D vs. Normal	**Normal Violin Chinrest and 3D-printed Violin Chinrest**					**t**	**df**	**Sig. (2-tailed)**
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Side-Mounted Chinrest	-0.37333	0.63839	0.11655	-0.61171	-0.13496	-3.203	29	0.003
Semi-Centered Chinrest	-0.43333	0.68246	0.12460	-0.68817	-0.17850	-3.478	29	0.002
Centered Chinrest	-0.44000	0.78635	0.14357	-0.73363	-0.14637	-3.065	29	0.005

Table 3 above shows the t-test comparison of 3D-printed Violin Chinrest and Normal Chinrest in terms of characteristics. It is evident that the p-value of each indicator is less than the significance level of 0.05. The null hypothesis is rejected. Therefore, there is a significant difference between the characteristics of 3D-printed Violin Chinrest and Normal Chinrest.

Table 4: t-test of the overall perception to 3D-printed Chinrest and Normal Violin Chinrest

3D vs. Normal	**Normal Violin Chinrest and 3D-printed violin chinrest**					**t**	**df**	**Sig. (2-tailed)**
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Side-Mounted Chinrest	0.73333	0.73968	0.13505	0.45713	1.00953	5.430	29	0.000
Semi-Centered Chinrest	0.33333	0.66089	0.12066	0.08655	0.58012	2.763	29	0.010

Centered Chinrest	0.40000	0.56324	0.10283	0.18968	0.61032	3.890	29	0.001

Table 4 above shows the overall perception to the 3D-printed Chinrest and Normal Violin Chinrest. It is evident that the p-value of each indicator is less than the significance level of 0.05. The null hypothesis is rejected. Therefore, there is a significant difference between the overall perception of 3D-printed Violin Chinrest and Normal Chinrest.

Table 5: Comparison in Weight Between Normal Chinrest and 3D-printed Chinrest

Type of Chinrest	Normal Chinrest	3D-printed Chinrest
Side-Mounted Chinrest	45 grams	30 grams
Semi-Centered Chinrest	45 grams	38 grams
Centered Chinrest	55 grams	50 grams

Table 5 above shows the comparison between the weight of the commercially available violin chinrest and the 3D-printed violin chinrest. For the basis weight of the normal chinrest, the specification of violin chinrest stated in the market was used while the 3D-printed violin chinrest used a weighing scale.

Table 6: Comparison in Weight Between Normal Chinrest and 3D-printed Chinrest

Type of Chinrest	Normal Chinrest (Php)	3D-printed Chinrest (Php)
Side-Mounted Chinrest	1200	600
Semi-Centered Chinrest	1400	800
Centered Chinrest	1200	700

Table 6 above shows the price comparison between commercially available violin chinrests and 3D-printed violin chinrests. For the basis pricing of normal chinrest, the researcher uses Amazon, an online shopping platform, to know the price of the normal chinrest since most violinist players buy their chinrest outside the Philippines. For the basis pricing of the 3D-printed chinrest, a quotation from ADEAS was used. ADEAS is a type of business/marketing that sells 3D-printed objects. It uses online platforms like FB page as a marketing strategy. The researcher consulted ADEAS for the pricing of the 3D-printed chinrest and came up with the price stated in the table above.

Table 7: Overall Mean of Normal Violin Chinrest

Pain	Mean	Rank	Verbal Interpretation
Neck Pain	2.44	1	Mild Pain
Jaw Pain	2.34	2	Mild Pain
Chin Pain	1	3	No Pain

The mean of overall data with the different kinds of pain and the degree of pain that violinists are experiencing while using a normal violin chinrest is shown in Table 7 below. It displays that neck pain has been found with the highest degree of pain that violinists are experiencing, with a weighted mean of

2.44 and a mild degree of pain, followed by jaw pain, with a weighted mean of 2.34 and mild pain. Lastly, no pain experience with a weighted mean of 1 is the chin.

Table 8: Overall Mean of 3D-printed Violin Chinrest

Pain	Mean	Rank	Verbal Interpretation
Neck Pain	1.47	1	No Pain
Jaw Pain	1.39	2	No Pain
Chin Pain	1	3	No Pain

While Table 8 shows the mean of overall data with the different kinds of pain and the degree of pain that violinists are experiencing while using a 3D-printed violin chinrest. It shows that neck pain has been found to have the highest degree of pain that violinists are experiencing, with a weighted mean of 1.47, followed by jaw pain, with a weighted mean of 1.39. Lastly, with a weighted mean of 1, is the chin. All of their verbal interpretations are no pain.

Table 9: Overall Mean Comfortability Between Normal Chinrest and 3D-printed Chinrest

INDICATOR	Mean of Normal Violin Chinrest	Descriptive Equivalent	Mean of 3D-printed Violin Chinrest	Descriptive Equivalent
Side-Mounted Chinrest	5.68	Comfortable	6.05	Comfortable
Semi-Centered Chinrest	5.70	Comfortable	6.13	Comfortable
Centered Chinrest	5.87	Comfortable	6.31	Comfortable
OVERALL	5.75	Comfortable	6.33	Comfortable

Table 9 above shows the overall summary of the violin chinrest. All of the indicators are in favor to the 3D-printed Violin Chinrest. Overall, 3D-printed Violin Chinrest got a higher rating of 6.33 compared to the normal chinrest of 5.75.

4. Conclusion and Recommendations

Based on the findings, the following conclusions are drawn, the ergonomically designed chinrest using additive manufacturing causes no pain to the violinist, rather than the normal chinrest causes mild pain to the violinist. It is more comfortable to used based on the overall mean compared to the normal violin chinrest in terms of sided, semi centered and centered chinrest. These are low cost compared to the normal the chinrest in terms of sided, semi centered and centered chinrest. In terms of side, semi-centered, and centered chinrest, the ergonomically designed chinrest using additive manufacturing is lighter than the normal chinrest. There is a significant difference between the characteristic of the ergonomically designed chinrest using additive manufacturing and normal violin chinrest. There is also a significant difference between the overall perception of the ergonomically designed chinrest using additive manufacturing and the normal violin chinrest.

The study concludes that the ergonomically designed chinrest using additive manufacturing is fitted only to the violinist player of Jose De Piro Kabataan Orkestra because, as a result of this study, the pain of the violinist is lessened and the comfortability of the violinist using ergonomically designed chinrest is better than their normal chinrest because the design parameters of making ergonomically designed chinrest are their own anthropometric measurement and also chinrest should alleviate discomfort and protect against injury. It is essential that they be correctly selected. When selecting a chinrest, the player's anthropometric dimensions are of the utmost importance. Furthermore, proper playing technique is essential. When playing, movement is critical; if a musician does not move correctly, it will affect both the music and their physical health.

In order to help the ergonomically designed chinrest using additive manufacturing be more comfortable, violinists must apply the following considerations, first, the violinists must use shoulder rest to avoid injuries to their collarbones and meet the highest comfortability while playing the violin. Second, the violinists must be aware of proper posture when playing the violin, whether they are sitting or standing. Lastly, is to use a stainless-steel violin clamp to avoid fiddlers' neck or irritation on the neck skin.

Moreover, the following ideas are suggested by the researchers in order to improve the ergonomically designed chinrest using additive manufacturing. Future research can adopt the statements below for further research. The numbness got the lowest mean in the ergonomically designed chinrest using additive manufacturing. It is recommended to improve the device to lower the numbness experienced by violinists. Comfortability got the lowest mean for the ergonomically designed chinrest using additive manufacturing. It is also recommended to focus on improving the comfortability of the chinrest when used as a semi-centered violin chinrest. The ergonomically designed chinrest should tailor-fitted to the anthropometric measurement of the violinist. Use a large scale of respondents and design different sizes and use their anthropometric measurement as a guide in making ergonomically designed chinrest. The future researcher can adapt this study to the customization of violin chinrest.

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