TRANSMISSIBILITY OF ISO 10819 PALM ADAPTERS MADE FROM CONVENTIONAL AND 3D PRINTED MATERIALS

Simon Kudernatsch, Takafumi Asaki, Donald R. Peterson*
Biodynamics Laboratory, University of Connecticut Health Center
Farmington, CT 06030-2017 USA

Introduction

Palm adapters are one of the essential tools needed for evaluating the effectiveness of vibration reduction gloves in accordance to the international standard ISO 10819[1]. Various materials used to manufacture palm adapters have been reported and include titanium[2, 3], magnesium[4], and acrylic[5], where Reynolds et al.[5] manufactured 30 acrylic palm adapters of varying shapes and dimensions in order to evaluate the influence of adapter geometry on transmissibility. They demonstrated that changes in adapter geometry effected bare-hand transmissibility but did not significantly influence glove transmissibility results. Rigid materials such as wood or hard plastics are recommended in the latest version of the standard[1]; however, the complex surface geometry and a misleading technical drawing of the palm adapter that requires advanced manufacturing capabilities in order to meet the dimensions, weight, and transmissibility constraints. This investigation compares the transmissibility of palm adapters manufactured using typical materials via conventional machining methods as well as palm adapters manufactured using additive manufacturing methods (i.e., 3D printing).

Methods

A total of eight palm adapters of varying materials were manufactured by conventional machining methods and additive manufacturing methods that included PolyJet 3D printing (Object30, Stratasys Ltd., Edina, MN) using a photopolymer (VeroWhitePlus FullCure®835) and fused deposition modelling (FDM; MakerBot Replicator 2 and 2X, MakerBot Industries, Brooklyn, NY) using polylactic acid (PLA) and acrylonitrile butadiene styrene (ABS). The material, weight, approximate density, and manufacturing method for each are listed in Table 1. Note that FDM printers are capable of printing parts of varying infill structure densities and only the palm adapters printed at 50% infill density are reported in this abstract. Given the inconsistency of the dimensions provided in ISO 10819, adapters were manufactured to the specifications as close as possible and critical dimensions such as the upper and lower profile radii (26±2 mm and 16 mm, respectively) and the overall length were maintained within the given tolerance, especially for the 3D printed adapters. Figure 1 shows an example of a 3D printed adapter using FDM along with an embedded tri-axial accelerometer Model 35A (Endevco, Meggit PLC, Hampshire, UK). The transmissibility of the palm adapters was tested using the vibration spectrum in ISO 10189 and following the Method 1 transmissibility measurement for both rubber tourniquet mounting and bare-hand mounting methods[1]. Transmissibility results were corrected using the transmissibility of the vibratory handle measured by mounting accelerometers on the back and front of the handle.

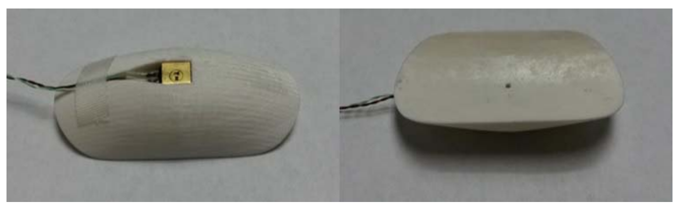

Figure 1 3D printed PLA palm adapter using FDM

Results

In the tourniquet-mounted adapter transmissibility test, the oak and polycarbonate adapters did not meet the criteria, while the 3D printed adapters using PLA and ABS provided the flattest frequency response spectrum, both between 0.96 and 1.03. In the bare-hand adapter transmissibility tests, none of the adapters met the specified limits; however, both PLA and ABS

Palm Adapter #	Material	Weight (g)	Density (g/cm^3)	Manufacturing Method
1	Acrylic	13.96	1.2	Conventional Machining
2	Oak	8.40	.56	
3	Pine	5.77	.34	
4	Polycarbonate	14.80	1.2	
5	Sugar Maple	8.46	.49	
6	VeroWhitePlus	12.80	1.18	PolyJet
7	PLA	9.21	1.32	FDM
8	ABS	6.81	1.05	

Table 1 Material, weight, approximate density, and mfg. method

yielded the flattest frequency response of the group. The PLA adapter was between 0.93 and 1.01 and failed at the 830 Hz and 1000 Hz bands in the 1/3 octave band spectrum, where the transmissibility was 0.944 and 0.939 respectively. The ABS was between 0.92 and 1.1 and failed at the 25, 31.5, and 40 Hz bands with transmissibility of 0.926, 0.93 and 0.946, respectively, and at the 1000 and 1250 Hz bands with transmissibility of 1.065 and 1.096 respectively. The plotted results of all adapters tested by both methods are shown in Figure 3.

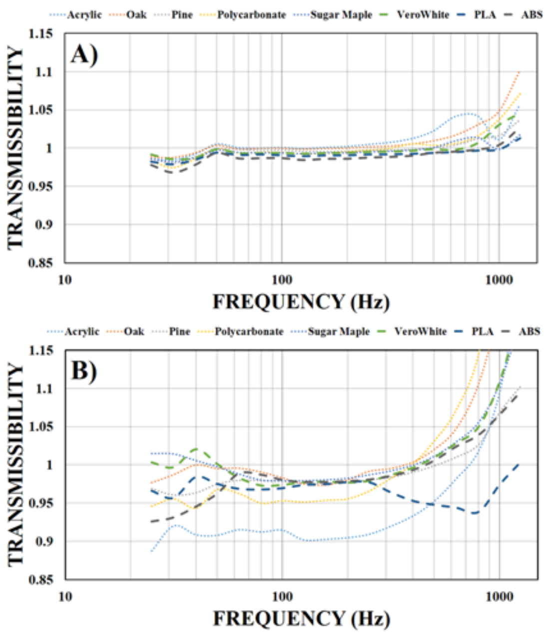

Figure 3 Tourniquet-mounted palm adapter (A) and bare-hand palm adapter (B) transmissibilities

Discussion

The differences between the tourniquet-mounted and bare-hand adapter tests are due to the added biodynamic response of the hand. Overall, the 3D printed adapters using FDM (i.e., PLA and ABS) provide the flattest frequency response in both tests suggesting that this method can suitably replace conventional manufacturing methods for palm adapter construction. Additive manufacturing methods used to generate palm adapters are time and cost efficient and, if universally adopted, promote a consistent construction of the ISO palm adapter and may help to minimize the variation in glove testing results observed between testing facilities. In addition, the reduced weight of the 3D printed palm adapter may also minimize measurement error, since heavier adapters may yield incorrect values due to a higher apparent mass, especially when coupled with thicker material gloves. Also, 3D printing allows for a quick adjustment and manufacture of palm adapters with various profile radii in order to better interface thicker or thinner gloves tested with the 40 mm diameter ISO 10819 handle and provide a uniform contact area and more consistent results.

References

1. ISO 10819: 2013, Method for the measurement and evaluation of the vibration transmissibility of gloves at the palm of the hand. International Organization for Standardization, Geneva, Switzerland.
2. Smutz W.P., Dong R.G., Han B., Schopper A.W., Welcome D.E., Kashon M.L. A method for reducing adaptor misalignment when testing gloves using ISO 10819. Ann Occup Hyg. 2002, 46(3):309-15.
3. Dong R.G., Rakheja S., Smutz W.P., Schopper A., Welcome D., Wu J.Z. Effectiveness of a new method (TEAT) to assess vibration transmissibility of gloves. Int J Ind Ergonomics. 2002, 30(1):33-48.
4. McDowell T.W., Dong R.G., Welcome D.E., Xu X.S., Warren C. Vibration-reducing gloves: Transmissibility at the palm of the hand in three orthogonal directions. Ergonomics. 2013, 56(12):1823-40.
5. Reynolds D.D., Wolf E. Evaluation of antivibration glove test protocols associated with the revision of ISO 10819. Ind Health. 2005, 43(3):556-65.

[Work supported by the National Institute for Occupational Safety and Health research grant 5R01 OH008997]

5th American Conference on Human Vibration

June 10 - 13, 2014 - University of Guelph, Ontario, Canada

Proceedings of the Fifth American Conference on Human Vibration

University of Guelph
Guelph, Ontario, Canada

Edited by Michele Oliver, Ph.D., P.Eng.
School of Engineering, University of Guelph
Guelph, Ontario

This activity is an Accredited Group Learning Activity (Section 1) as defined by the Maintenance of Certification program of The Royal College of Physicians and Surgeons of Canada and approved by Occupational Medicine Specialists of Canada (OMSOC). The activity has been approved for up to 13 hours for the 3 day course (1 credit per hour).

Forward – Welcome Address

On behalf of my conference co-chairs, I am pleased to welcome you to Guelph, Ontario, Canada for the 5th American Conference on Human Vibration. The 5th ACHV is being co-hosted by the University of Guelph, Laurentian University, Western University and the University of Toronto. We are honored to be hosting this biennial conference on the University of Guelph campus. As the premier North American conference for human exposure to vibration, the conference provides a unique and convenient opportunity for researchers, engineers, medical professionals and industry representatives to exchange information on all aspects of vibration control and human responses to hand-transmitted vibration and whole-body vibration. The theme for this year's meeting is "Human Vibration - From Theory to Industrial and Clinical Applications".

Founded in 1827, Guelph was named after the British Monarch King George IV, who was from the House of Hanover. Selected as the headquarters of a British development firm called "The Canada Company", Guelph was designed by John Galt, who was a Scottish Novelist. The town was designed to resemble a European city center comprised of squares, wide main streets and narrow side streets. Guelph was home to Lieutenant Colonel John McCrae, the author of "In Flanders Fields". Its references to the red poppies that grew over the graves of fallen soldiers resulted in the remembrance poppy becoming one of the world's most recognized memorial symbols for fallen soldiers. Guelph was also the home of North America's first cable TV system. Fredrick T. Metcalf created MacLean Hunter Television (now part of Rogers Communications) and their first broadcast was of current monarch Queen Elizabeth II's Coronation in 1953. With a population of over 120,000, Guelph is part of a technology triangle which is comprised of the cities of Guelph, Kitchener, Cambridge and Waterloo. Guelph is consistently rated as one of Canada's best places to live because of its low crime rate, clean environment, high standard of living and low unemployment rate. Almost one quarter of Guelph employment is provided through the manufacturing sector with over 10% provided through Educational services. The City of Guelph has identified life science, agri-food and biotechnology, environmental management and technology companies as industries on which to focus future economic development activities.

Many thanks to Elyse Dubé from Conference Services at the University of Guelph for all of her hard work in helping to plan and sort through the conference logistics. We'd also like to thank Guelph Engineering students Gregor Scott and Dan Leto as well as School of Engineering technician Carly Fennell for their help in setting up the laboratory tours. We hope that your visit to the 5th ACHV and Guelph will be both educational and enjoyable.

Sincerely,

Michele Oliver, Jim Dickey, Tammy Eger and Aaron Thompson