Research Article

Journal of Medical - Clinical Research & Reviews

Muscoloskeletal Disorders of the Hand and Wrist in Ophthalmologists

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Received: 16 January 2018; Accepted: 13 February 2018

Citation: Murad A Sunalp. Muscoloskeletal Disorders of the Hand and Wrist in Ophthalmologists. J Med - Clin Res & Rev. 2018; 2(1): 1-3.

Keywords
Ophthalmologists, Muscoloskeletal Disorders, Disease Control.

Introduction
The Center for Disease Control and Prevention (CDC) in review separates musculoskeletal disorders (MSDs) of the hand/wrist region into three components for the purpose of this review: (a) Carpal Tunnel Syndrome (CTS), (b) Hand/Wrist Tendinitis, and (c) Hand-Arm Vibration Syndrome (HAVS) (https://www.cdc.gov/niosh/docs/97-141/pdfs/97-141e.pdf).

Exposure to vibrating hand-held tools can cause a variety of vascular and neuromuscular symptoms collectively named Hand-Arm Vibration Syndrome (HAVS). The general impression of occupational injuries, such as HAVS is that such injuries are associated with occupations that expose the worker to intense vibrational force, such as the use of power drills, chain saws and jackhammers; it is easily recognized that such activities in an occupational setting can cause acute direct stress and trauma to a tissue and could lead to functional disability. What is more difficult to recognize are HAVS can result from long-term minor or submaximal application of vibrational stress to a tissue. Long-term submaximal vibrational stress will lead to asymptomatic microtrauma and a localized inflammatory response, since the effects are cumulative and if exposure to vibration continues over months or years, the symptoms can worsen and become permanent. The clinical presentation of HAVS syndrome includes paraesthesiae or tingling in digits, pain or tenderness in the wrist and hand, digital blanching, cold intolerance, weakness of the finger flexors or intrinsic muscles and discoloration and trophic skin lesions of the fingers [1].

It has been shown that in addition to vascular and neurological damage, damage to the musculoskeletal system contributes significantly to upper extremity problems and disability [2] and diminished [3,4].

Repetitive exposure to low levels of vibrational force has been reported to be associated with HAVS in dentists [5] and in radiology technologists [6]. I addition to repetitive exposure to vibration, posture during exposure can aggravate the harmful effects of vibration.

An editorial in Review of Ophthalmology (October 2011) reports on a number of studies dating to 1994 indicating that a significant number of ophthalmologists suffer from several occupational-related disorders including chronic headaches, back pain, with those longest in the field having more frequent back pain, neck, upper body or lower back symptoms, which in some cases required surgery and/or limiting their surgical practice.

Since the hand-arm vibration acceleration (HAV) that has been shown to cause HAVS ranges from 5 to 36 m/sec^2, here we have documented the vibrational force borne by the ophthalmologist during cataract surgery, which repeated over the professional life can result in HAVS as well as carpal tunnel syndrome and other disorders. The CDC defines HAV "as the transfer of vibration from a tool to a worker's hand and arm. The amount of HAV is characterized by the acceleration level of the tool when grasped by the worker and in use. The vibration is typically measured on the handle of tool while in use to determine the acceleration levels transferred to the worker" (https://www.cdc.gov/niosh/docs/97-141/pdfs/97-141e.pdf).

Methods
Measurements were made using the Alcon Centurion Phaco unit with an OZil Infiniti hand piece (Alcon Laboratories, Fort Worth, TX). We measured low-frequency vibrations (m/s^2) at 4, 7, 10 and 13 cm from the tip for both low and high frequency vibration during 10 phacoemulcification procedures, each procedure lasting

on average 22.5 minutes (range 15-30 minutes).

Results

Vibration energy of the Ozyl Infiniti hand piece during phacoemulsification. The data in Table 1 shows the acceleration of low frequency vibrations at various point from the tip of the OZil Infiniti hand piece measured during 10 phacoemulcification cataract surgeries; note that the vibration increases significantly from 4 cm from the tip toward the base, from an average of 1.34 to 2.4 m/sec^2 (p=>.28669).

Acceleration m/s^2 (Low Freq)

Base	4m	7m	10m	13m
Tip	0.6	0.7	0.8	1.3
	0.8	2.3	2.1	2.7
	0.4	1.2	1.4	3.7
	1.4	3	1.6	2.5
	3.2	2.4	1.3	2.8
	0.8	0.9	1.1	1.1
	0.6	2.1	1.8	3
	3.4	2.2	1.3	2.5
	1.6	3.2	2.2	2.2
	0.6	1	1	2.2
Average	1.34	1.9	1.46	2.4
Range	0.4-3.4	0.7-3.2	0.8-2.2	1.1-3.7
SD	1.099697	0.893184	0.462361	0.767391
TOTAL VALUES	Average		1.775	
	Range		0.4-3.7	
	SD		0.909142	

Table 1: Acceleration of low frequency vibration measure at 4, 7, 10 and 13 cm from the tip of the OZil Infiniti hand piece (total length of the OZil hand piece is 15.24 cm). p = .28669.

Table 2 shows the acceleration of high frequency vibrations at various points from the tip of the OZil Infiniti hand piece during 10 phacoemulcification procedures for cataract surgery. Vibration increases significantly from 4 cm from the tip toward the base, from an average of 1.26 to 2.7 m/sec2 (p=>.00218).

Acceleration m/s^2 (High Freq)

Base	4m	7m	10m	13m
Tips	1.8	3.1	2.1	3
	0.5	2.5	3.4	3.2
	1.4	2.3	2.5	3.9
	1.6	1.8	3	1.4
	0.8	1.6	1.7	1.9
	2	1.8	1	2.1
	0.7	1.5	2.8	1.3
	1.2	3	2.2	3.7
	0.6	2.8	3.4	3.4
	2	1.6	2.2	3.1
Average	1.26	2.2	2.43	2.7
Range	0.5-2	1.5-3.1	1.0-3.4	1.3-3.9
SD	0.583476	0.618241	0.755792	0.947511
TOTAL VALUES	Average		2.1475	
	Range		0.5-3.9	
	SD		0.898428	

Table 2: Acceleration of high frequency vibration measure at 4, 7, 10 and 13 mm from the tip of the OZil Infiniti hand piece (total length of the OZil hand piece is 15.24 cm). p = .00218.

Discussion

Hand-Arm Vibration (HAV) is the transfer of vibration from the tool to the tool holder fingers, hand and arm. Many studies have shown that exposure to HAV increases the rate of HAVS significantly. The majority of studies of the relationship of HAV to HAVS have been done on workers using large tools, such as workers in the lumber industry using chain saws [7,8], stone-cutters using rock drills and chisel hammers [9], and hand tools used in the automobile industry [10]. Vibration from tools used in these industries is higher that vibration produced by tools used by dentists or ophthalmologists; however, HAVS is dependent not only on the intensity of the vibration, but also on duration of exposure, variation of intensity over time, work methods, work processes, and posture during use.

Experimental evidence indicate that neurological, vascular, and musculoskeletal damage may result from direct injury to the peripheral nerves, nerve endings, and mechanoreceptors, and digital blood vessels producing symptoms of pain, and loss of sensitivity. Damage to digital blood vessels results in thickening of the blood vessel walls and loss of sensitivity [11,12]. Numbness and tingling of hand and fingers, which characterize HAVS, may be secondary to vascular constriction of the blood vessels, resulting in ischemia in the nerve-end organs [13-15].

The question of whether or not vibration from the hand piece used in cataract surgery results in significant number of ophthalmologists suffering from HAVS remains to be determined. However, it is important to consider that over 30-40 years of practice, a high volume cataract surgeon is exposed to significant vibrational

stress, especially when using older hand pieces that vibrate continuously. Certainly, it would be desirable for the industry to consider spending some research efforts into the manufacture of hand pieces with reduced vibrational force.

Acknowledgment

Special thanks to technicians Chris and Ed.

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