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Study On Vibration Massage To Make Shaving More Comfortable

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Abstract *— Shaving is a daily routine for adult men, and most of them have encountered discomfort caused by manifestations. A common discomfort is shaving burns, burns after shaving, even redness, swelling, and inflammation. It is mainly due to the adverse effects of the razor on the skin caused by irritation. This paper proposes using a vibrating device to massage the face before shaving to relieve skin irritation. Two evaluation methods were used in the study, sound spectrum analysis and mean opinion score (Mos) test. Sound spectrum analysis is used to analyse the working status of the razor objectively. The tester's Mos test can reflect people's subjective feelings about the comfort of shaving. The results show that vibration massage can make the beard more easily cut, reducing the skin's sensitivity and discomfort. Vibration massage can make shaving easier and more comfortable.*

Keywords — *Vibration Massage, Wet Shave, Comfort, Sound Spectrum Analysis, Mos Test.*

I. INTRODUCTION

Acoustic vibration equipment is more and more widely used in life, mainly used for massage and cleaning. On the one hand, for massage, such as a fascia gun, a massage chair is used for muscle relaxation, and a facial vibration massager is used for shrinking wrinkles and beauty. On the other hand, for cleaning, sonic vibrating toothbrushes, and vibrating face brushes, these vibrating devices are used for teeth and face cleaning. In medical and industrial applications, such as ultrasonic removal of stones and cleaning of precision instruments. According to the research of the paper [1] [2], the oscillating mechanical stimulus applied on the skin surface can induce changes in the expression of some structural proteins, which has an anti-aging effect on the skin. In this paper [3], vibration can increase skin moisture and effect and increase skin moisture. According to Short et al., the mechanical organization of the skin is a large number of loose collagen fibres connected at randomly distributed nodes [4]. The sonic skin brush can generate upward-opening force to achieve a profound cleansing effect [5]. Some studies have shown that it may improve inflammatory diseases, including acne vulgaris and skin damage related to excessive exposure to external light and pollution [6]. All in all, this shows that proper vibration is good for the skin. In addition to these traditional application areas, this article also applies them to shaving. Tidying up beards is a problem that every adult man needs to face. Not only do people need sharp blades, but they also need appropriate techniques to shave smoothly and comfortably. The most common problem encountered during shaving is shaving burns. It means that the skin will feel burning and pain after shaving. This is the response of the razor to skin irritation. Therefore, to reduce razor irritation, the traditional method is to use emollients when shaving and skincare lotion after shaving. [7] [8]

This paper aims to study the effect of using sonic vibration equipment to massage before shaving to relieve the irritation of shaving burns. The sonic vibration device can make shaving easier and reduce the irritation of the razor to the skin. Chapter 2 introduces the causes of skin irritation induced by manual razors. Chapter 3 explains the principle of vibration massage to relieve skin irritation. Chapter 4 introduces the evaluation methods of shaving comfort. First, objective evaluation is made by the sound spectrum analysis of the vibration sound when the razor is working. Second, the Mos test is performed on all testers, and the shaving comfort is scored objectively. Chapter 5 performs sound spectrum analysis and Mos test on the tester，and gets the result. Chapter 6, Conclusion.

II. CAUSES OF SKIN IRRITATION INDUCED BY MANUAL RAZORS

Shavers are divided into manual shavers (wet shave) and electric shavers (Beard trimmer). Compared to electric shavers, wet shaving is a more traditional way. The manual shaver is mainly composed of a cutter head and a handle, and the cutter head is divided into single blade and multi-blade. When shaving, people drag the knife handle to make the head slide on the skin, the blade is at a certain angle with the skin, and the force of dragging the blade causes the blade to cut the hair. Then repeat this operation until the shaving is complete. The skin irritation caused by the razor comes from the contact between the blade and the skin. The blade's cutting mainly comes from the pressure and pulling force applied to the knife handle. The pressure press down on the skin and the pulling force is ultimately used to resist the friction between the skin and the blade and the resistance of the beard against the blade. Then, the resistance is converted into the pulling force of the blade pair and the beard. As shown in Figure 1, for a multi-blade wet shave, the pulling force of the front blade on the hair lifts a part of the hair and then cuts it off. The final cut hair will be hidden under the skin. The blade and skin friction and the pulling force of the blade on the hair are the main sources of irritation. The smoothness of the skin and the pressure applied determine the amount of friction. To reduce the resistance of the beard to the blade, the blade should be sharper, or the beard should be softer and easier to cut. [9] [10]

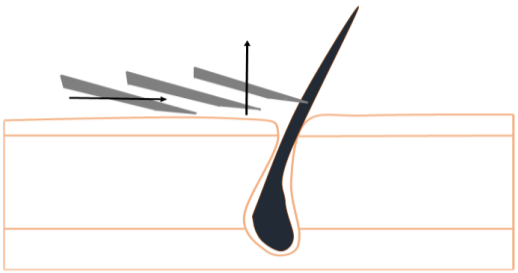

Fig. 1. The working principle of shaver with multiple blade

III. ACOUSTIC RESONANCE MASSAGE RELIEVES SKIN IRRITATION

The vibrating device directly applies mechanical force to the skin to perform work periodically. Because the main body of the human body is water occupies 70%, this mechanical vibration will cause the resonance of cells and tissues through the amplification of the human body. Resonance can cause the movement of substances in the tissue cells to achieve the massage effect in the cells. This massage effect can change the cell membrane. Permeability stimulates the diffusion process of cell semipermeable membrane and promotes metabolism. It can promote the secretion of oil and water and make the hard connective tissue soft. When the mechanical energy of vibration is transmitted in human tissues, its energy is finally converted into heat, and the heat energy generated by the friction between the massage equipment and the skin increases the temperature of the massaged part. Elevated temperature further increases blood circulation, dilation of capillaries and pores. That is to say, the mechanical energy of vibration massage can not only make the skin secrete water and oil, make the skin soft, smooth, and elastic [3]. Heat can also relax the pores and change the protein fibre structure of the hair to soften the hair. This solves the problems of skin friction and hair cutting resistance. [11] [12]

IV. EVALUATION METHOD

A. Vibration and sound spectrum analysis method

The traditional evaluation methods for shaving effect mainly include sebum measurement, corneal measurement, epidermal water loss (TEWL), infrared thermal imaging, and high-frequency ultrasonic sound waves. These methods directly observe and analyse the material composition and content on the skin surface. However, sound spectrum analysis is an indirect method. It does not directly observe the skin but reflects the working status and effect of the razor by analysing the sound components of the shaving sound. Vibration and sound spectrum analysis are often used in machine fault diagnosis, earthquake early warning, language signal analysis, and other fields. It can solve many problems that are difficult to observe directly. The structure of matter can be inferred by judging vibration and resonance because the frequency of matter is only related to its structure. Sound is a physical phenomenon, which is produced by the mechanical vibration of matter. The time-domain signal of sound is difficult to analyse, so it is necessary to perform time-frequency conversion to analyse in the frequency domain. The sound signal analysis methods include Fourier transform, short-time Fourier transform, discrete wavelet transform, continuous wavelet transform (CWT), Hill Bert transformation, Hilbert-Huang transformation. This paper uses the short-time Fourier transform (STFT) to construct the power spectral density of the sound signal. [13] [14]

The autocorrelation function (ACF) and the power spectral density function are a pair of Fourier transform. Thus, the autocorrelation function is calculated first, and then the power spectral density function can be obtained through the discrete Fourier transform.

$$F_n(K) \overset{DFT}{\Longleftrightarrow} R_n(k)$$

The following is the short-term autocorrelation function. The short-term refers to multiplying by a window function to intercept the signal and perform autocorrelation calculation at the same time.

$$R_n(k) = \sum_{m=-\infty}^{\infty} x(m)W(n-m)x(m+k)W(n-m+k)$$

It can be defined as:

$$h_k = W(n)W(n+k)$$

So, the short-term autocorrelation function can be rewritten as a convolutional expression.

$$R_n(k) = \sum_{m=-\infty}^{\infty} x(m)x(m-k)h_k(n-m)$$
$$= [x(m)x(m-k)] * h_k$$

Therefore, the short-term autocorrelation function can be regarded as the output of the sequence $x(m)x(m-k)$ through the h_k filter. Where the W(n) is FFT windows.

Finally, the short-time autocorrelation function is subjected to discrete Fourier transform to obtain the power spectral density.

$$F_n(K) = \sum_{n=0}^{N-1} R_n(k)e^{-j\frac{2\pi}{N}Kn}$$

Using a fast Fourier transform (FFT) algorithm can reduce the calculation time. From the power density spectrum, the sound intensity of each frequency domain component can be observed, and the frequency composition of the sound signal can be understood. By observing the change of the spectrum component, the change of the working state of the machine can be inferred. [15]

B. Mos test

Mean Opinion Score (Mos) is used to evaluate the compressed voice quality received by the system. It is also widely used in humans' objective scoring of a certain event, and the average of all scores is used as the final score. It is generally a 5-point system, with 1 to 5 representing five different evaluation levels from low to high. In this paper, Mos is used for subjective evaluation of shaving comfort, and the comfort is divided into five levels. 1: terrible, 2:

uncomfortable, 3: normal, 4: comfortable, 5: excellent. Each subject will give a score based on his true feelings and finally get an average score, representing the subjective opinions of most people. [16]

V. EXPERIMENT AND DISCUSSION

The experiment subjects were one hundred adult males with beards, ranging in age from 20 to 63 years old. The experimental site is a quiet laboratory. The experimental device has three-blade wet shaving, vibration massage device, shaving soap, and recording equipment. The experiment is divided into two parts: the normal shaving process and the other part is the vibration massage shaving process. In order to control the variables, the experiment divided the tester's face into two experimental areas, requiring one side of the face to shave normally and the other side to shave after vibration massage. During the experiment, the shaving sound source collected by the recording equipment was sampled at 48khz and quantized to 16 bits, and the analysis software was Audition CS6. Use software to perform 256-point FFT on the sound source and use Hanning window to filter to obtain the analysis spectrum. Then all subjects scored the comfort of normal shaving and vibration massage shaving and got the Mos test result. Figure 2 is the experimental process.

Figure 3 shows the sound power spectrum of a tester after normal shaving and vibratory massage. X-axis means frequency (0Hz~2kHz), y-axis means sound intensity (dB). The solid red line is the spectral density curve of normal shaving, and the red dashed line is the spectral density curve of the predicted environmental background sound. Similarly, the solid blue line represents the spectral density curve of the shaving sound after vibration massage, and the blue dashed line represents the spectral density curve of the corresponding predicted environmental background sound. The shaving process caused sound resonance to gain the spectrum amplitude. According to the research of this paper [17], there are three resonance peaks, the first resonance peak is the natural frequency of the razor, and the second resonance peak is the razor blade. Friction with the skin generates a resonance frequency component. The third resonance peak is the resonance frequency component generated by the friction between the razor blade and the beard when the razor blade cuts the beard. In other words, the third formant is related to razor and beard cutting. For the third resonant peak, the bandwidth of the solid blue line (Bw2) is greater than the bandwidth of the red solid line (Bw1). In other words, when the skin is vibrated and massaged, the blade and the beard resonate. The spread spectrum appears. According to the experimental results, the average Bw1 is 3566HZ, and the average Bw1 is 9886HZ. The bandwidth of the frequency band has been expanded more than twice.

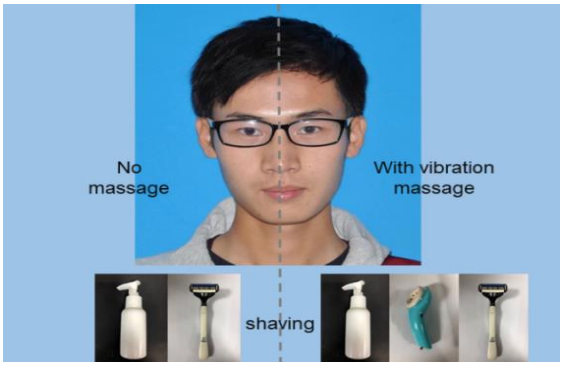

Fig. 2. Experimental Process

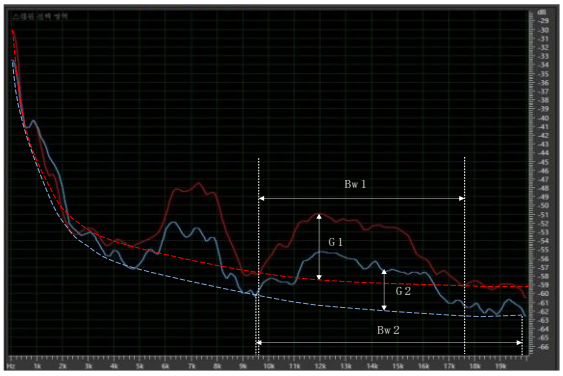

Fig. 3. The sound spectrum of general wet shave (red line) and the sound spectrum of wet shaved after the Vibration massage (blue line)

Regarding the amplitude gain of the third formant, G1 represents the amplitude gain of the third formant during normal shaving, and G2 represents the amplitude gain of the third formant after vibration massage. It can be seen from the figure that G2 is smaller than G1. Table 1 shows the average amplitude gain results of the third formant of all testers, including the average amplitude values before and after, the average gain size, and the average gain bias of shaving before and after vibration massage. The results show that the amplitude gain of normal shaving is +8.02dB. The amplitude gain of shaving after vibration massage is +4.25dB, and -3.77dB reduces the amplitude gain after vibration massage. The sound pressure level has been reduced by more than twice. That is, the resonance caused by the friction between the razor blade and the beard is reduced. It means that the resistance of the beard to the blade is reduced. Therefore, the beard becomes easier to be cut.

TABLE I. AMPLITUDE GAIN EFFECT

	Massage before	Massage after
Shaving	73.84 dB	84.66 dB
Normal	69.59 dB	76.98 dB
Gain	+8.02 dB	+4.25 dB
Bias（after- before）	-3.77 dB	

Table 2 is about the Mos test result of shaving comfort. It shows the scores and average scores of some testers on the comfort of the two shaving methods. Most subjects rated the shaving before the massage as 1 or 2. The average score is 1.35, which means that the comfort level of shaving before the massage is uncomfortable or even terrible. On the contrary, the score for shaving before the massage is relatively high, with an average score of 4.35, which indicates that the comfort level of shaving before the massage is comfortable. The results of the Mos test found that the comfort evaluations before and after the massage were very different. In addition to vibration massage that makes shaving easier, it can be guessed that vibration massage reduces the skin's sensitivity, relaxes the nerves, and enhances autonomic nerve regulation, thereby reducing the degree of response to razor stimulation. [1]

TABLE II. MOS TEST RESULT

	Massage before	Massage after
1	1	4
2	2	4
3	2	5
4	1	3
5	1	4
6	1	5
7	2	5
…	…	…
100	3	5
Average	1.35	4.35

VI. CONCLUSION

Discomfort during shaving may be a common problem encountered by most adult men. This paper proposes use a vibrating massage device to massage the face before shaving to make shaving easier and more comfortable. For the evaluation of comfort, use objective sound spectrum analysis and subjective MOS analysis.

Sound spectrum analysis analyses the sound emitted by the razor when it is working and uses the difference of the spectral components of the power spectral density to judge the working state of the razor. The results of sound spectrum analysis show that the third formant is produced by the resonance of the razor and the beard. After vibration massage, the bandwidth of the third formant is doubled, and the amplitude gain is reduced by half. In other words, the frictional resistance between the blade and the beard is reduced, and it becomes easier to cut the beard. This reduces the irritation of the beard pull on the skin and improves the comfort of shaving.

The MOS test results showed that most subjects felt uncomfortable during normal shaving, but the comfort was significantly improved after the vibration massage. This vast improvement may be related to vibration massage that can relax skin protein fibres and reduce skin sensitivity.

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