Effect of Skill Level Difference in the Polishing Process of the Maki-e Making Technique

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Abstract. In this research, "Maki-e" technique was focused. Maki-e technique is a decoration technique of Urushi crafts technique. There is a polishing process in the Maki-e making process. Maki-e surface is polished by a charcoal and whetstone in the polishing process. Time-served technique is needed for this process. Because this process affects a finish of Urushi crafts work, this research aimed to clarify a relationship between a skill level difference of craftspeople and a finish of Urushi crafts work in the polishing process by using charcoal. Characteristics of the finish Urushi crafts work and how to use a body of craftspeople was analyzed. As the results of this research, it was confirmed that; 1. The expert's Maki-e specimen was more brightness and yellow than the non-expert. 2. There was not much difference about the gloss and surface roughness between the expert and the non-expert. 3. The expert took the rhythmic activity in each muscle. Therefore it seemed that the finish of the work became more beautiful. These results suggest that how to use the body affects the finish of the Urushi crafts work in the polishing process. The non-expert can improve the finish of the work and the level of polishing skill by training the body position and motion like the expert.

Keywords: Urushi crafts · Maki-e · Polishing · Color · Gloss · Surface roughness · Electromyogram

1 Introduction

There are many traditional crafts in Japan. Urushi crafts is one of the Japanese traditional crafts. In the past, it was very famous in the world, Urushi resin and Urushi crafts work was called "japan". It was exported to the European countries by the East India Company et al. in the Age of Discovery about 400 years ago. As a result, Urushi crafts work collection was made by the royalty and the aristocracy. After Age of Discovery, Japan closed the country to foreign commerce, but Urushi crafts work continued to be exported to foreign countries

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through Netherlands, England, China et al. In the modern age, Urushi crafts work was focused once again because of the Japonisme and exhibition of the World Exposition. However Urushi crafts work is not used now because a synthetic resin and substitute material was developed. In this current situation, Urushi crafts work was collected and exhibited as an art or cultural property by the domestic and overseas museum and art museum.

To this day, Urushi crafts technique is needed to make a new work and repair or restore the old work now. This technique was kept by craftspeople. Craftspeople technique has much wisdom and knowledge called a knack and hunch. They are called the "implicit knowledge", and it takes a long time to understand and master them. Therefore, year of ascetic training for craftspeople is too long. And then researchers have turned implicit knowledge into explicit knowledge, they invent a new method of manufacturing base on it, and apply it to short-time ascetic training [1–4].

In this research, "Maki-e" technique was focused. Maki-e technique is a decoration technique of Urushi crafts technique. After painting an Urushi resin on the surface of base body, rough design is drawn by the mixture of raw Urushi and Bengal red powder. After that a metallic powder is sprinkled on the rough design. There is a polishing process in the Maki-e making process. Maki-e surface is polished by a charcoal and whetstone in the polishing process. Time-served technique is needed for this process. Because this process affects a finish of Urushi crafts work, this research aimed to clarify a relationship between a skill level difference of craftspeople and a finish of Urushi crafts work in the polishing process by using charcoal. Characteristics of the finish Urushi crafts work and how to use a body of craftspeople was analyzed. In the previous researches, physical property and polishing performance of the charcoal for polishing was analyzed [5], the body movement of polishing process was not analyzed yet. On the other hand, the difference of muscle activity of expert and non-expert's finger was pointed out in the sprinkling metallic powder process [6]. The relationship between a grip force of expert craftspeople and a surface roughness of industrial component was analyzed in the polishing process of the manufacturing industry [7]. As these results, this research is effective to making a high quality Urushi crafts work and training non-expert Urushi craftspeople.

2 Measurement

2.1 Subject

There were two subjects in this research. One was an expert Urushi craftspeople, the other was a non-expert Urushi craftspeople. They had engaged in the making Maki-e especially. Expert was a right-handed male, his age was 59 years old, and his year of experience was 41 years and 8 months. Non-expert was a right-handed female, her age was 25 years old, and her year of experience was 5 years and 8 months. They polished a sample which was sprinkled metallic powder and coated by Urushi as usual.

2.2 Maki-e Specimen

Figure 1 showed a Maki-e specimen. Left image is the specimen before polishing, right image is the specimen after polishing. Size of specimen was 100 mm × 100 mm × 5 mm.

Its base was PMMA (Polymethylmethacrylate) board. Its board was polished by a sand paper, rubbed with raw Urushi. After that, black Urushi (Kuro-Roiro-Urushi, made by Shikata Yoshizo Urushi Ten) was painted on the surface of the PMMA board in twice. After hardening the black Urushi, the surface was polished by the charcoal, and rubbed with Uwazuri Urushi (Reddish clear Urushi). After that, rough design was drawn by the bengal red Urushi (E-Urushi) and gold round powder (Maru-fun, No.8, made by Asano Shoten) was sprinkled on the rough design. One large center circle and eight small circles around center circle were designed. Its design was called “Kuyo-mon” in Japan. After hardening the bengal red Urushi, sprinkled gold powder was coated by yellowish clear Urushi (Nashiji Urushi) in twice for keeping the powder on a surface of Urushi painting. Lastly black Urushi was painted on the surface of specimen in twice.

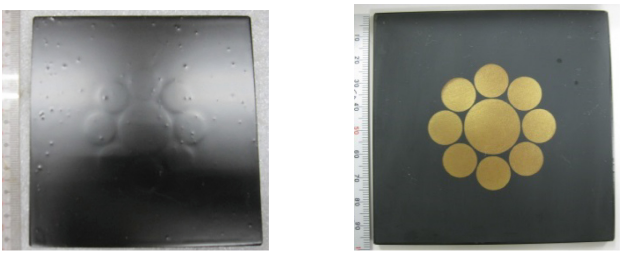

Fig. 1. Maki-e specimen

2.3 Colorimetry

Colorimetric value was measured by the Spectrophotometer CM-700d (made by KONICA MINOLTA, INC.). Light source was D65. A field of view was 2 degree. Measurement diameter was 3 mm. Figure 2 showed a measurement point. L*, a* and b* values of five points were measured. This device measured by the integrating sphere, the data including a specular light data was analyzed.

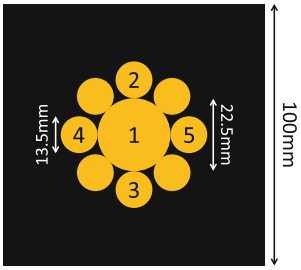

Fig. 2. Measurement points of color measurement

2.4 Gloss

Gloss value was measured by the Gloss Checker IG-331 (made by HORIBA, Ltd.). Because a surface of Urushi crafts work was high glossy, the specimen was measured with an incident and receiving angle: 20 degree. This measurement angle was convenient for measuring a high glossy subject. Light source was LED, and its wavelength was 890 nm. Measurement range was a shape of an ellipse, its major axis was 4 mm, and minor axis was 3 mm. Measurement point was the center of large circle, it was measured five times.

2.5 Surface Roughness

Surface roughness was measured by the Dektak XT (made by Bruker Corporation). Scan mode was Standard Scan, vertical measurement rage was 65.5 μm, measurement distance was 2 mm, measurement time was 10 s. Center of center large circle was measured in twice, and center of one of the small circles was measured one time. Data was analyzed by the IGOR Pro Version 6.3.4.1 (made by WaveMetrics, Inc.), and the root mean square surface roughness was calculated.

2.6 Electromyogram

Electromyogram was measured by the EMG multi-channel telemeter system WEB-1000 (made by NIHON KOHDEN CORPORATION) in the polishing process with the charcoal. Figure 3 showed the measurement muscles. Triceps brachii muscle, biceps brachii muscle, extensor muscles of the forearm, flexor muscles of the forearm, deltoid muscle, cowl muscle, pectoralis major muscle and interosseus muscle of the right arm and hand were measured in order to know the muscle activities when the subject polished a specimen with grasping the charcoal. Sampling rate was 1000 Hz. After measurement, a waveform of electromyogram was observed and compared with the movie. A difference, continuousness and pattern were analyzed. In addition, EMG of muscle activity was commuted, an average of 10 muscle activities was calculated, and was smoothed in the early, middle, final phase.

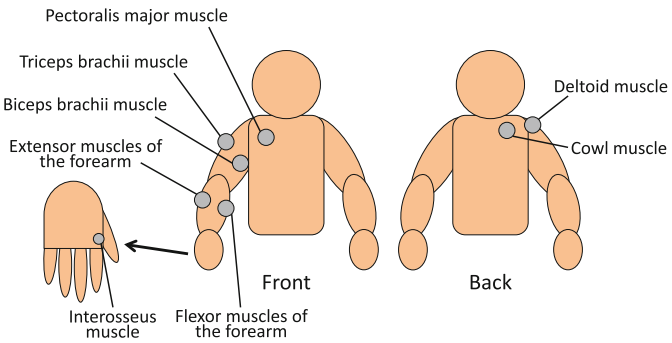

Fig. 3. Measurement muscles

3 Result

3.1 Colorimetry

Figure 4 showed a result of the colorimetry. L* value of the expert was higher than the non-expert. Specimen of expert was brighter than the non-expert. a* value of the expert was lower than the non-expert, and b* value of the expert was higher than the non-expert. Specimen of expert was more yellow than the non-expert. Specimen of the non-expert was more red than the expert.

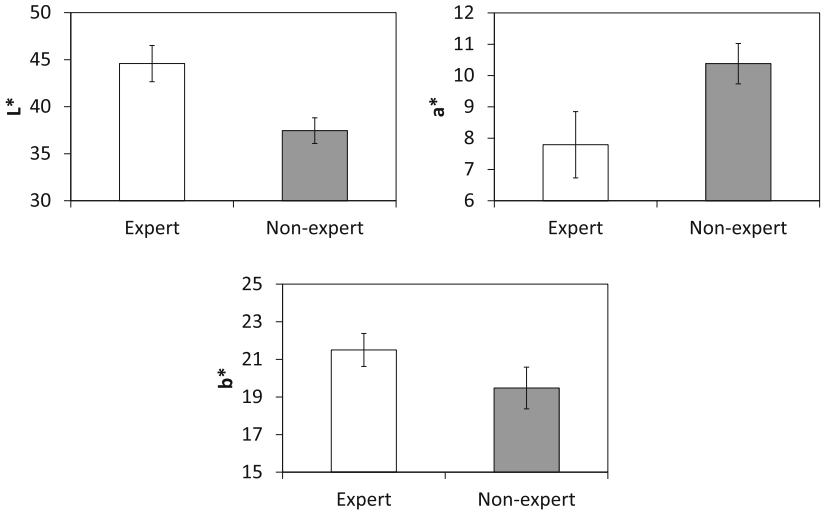

Fig. 4. Result of color measurement

3.2 Gloss

Figure 5 showed a result of the gloss. A value of gloss was very low in both the expert and the non-expert. The value was equal to or less than 1.0. The difference between them was very small.

3.3 Surface Roughness

Figure 6 showed a surface roughness curve of specimen. Surface roughness was large in both the expert and non-expert. Figure 7 showed a result of root mean square surface roughness (Rms). There was not so much of a difference between the expert and the non-expert.

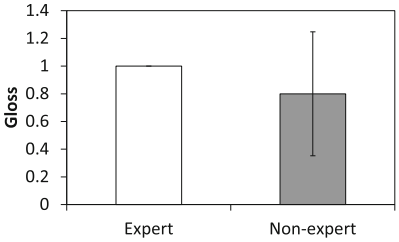

Fig. 5. Result of gloss measurement

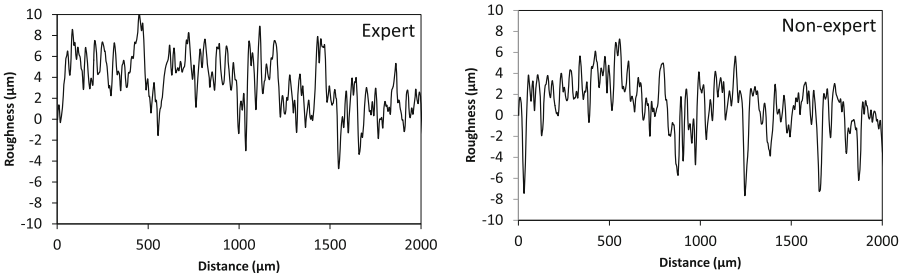

Fig. 6. Surface roughness curve

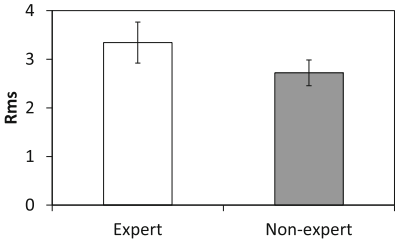

Fig. 7. Result of root mean square surface roughness

3.4 Electromyogram

Figure 8 showed the waveform of the electromyogram of the expert in each phase. Figure 9 showed the waveform of the electromyogram of the non-expert in each phase. Figure 10 showed the smoothed waveform of each muscle in the expert. Figure 11 showed the smoothed waveform of each muscle in the expert.

In the case of the expert, muscle activities except for the extensor muscles of the forearm were rhythmical in each phase. The biceps brachii muscle, flexor muscles of the forearm and interosseus muscle acted almost at the same time. Triceps brachii muscle, extensor muscles of the forearm, deltoid muscle, cowl muscle and pectoralis major muscle acted almost at the same time. It was clarified that the muscles acted and relaxed repeatedly from the complementarity of muscle. This was an alternate action of an antagonistic muscle.

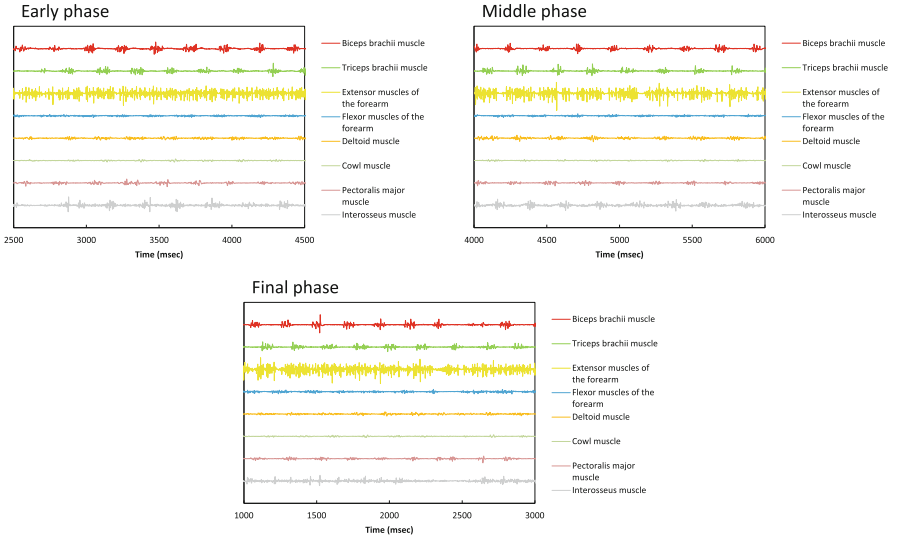

Fig. 8. Waveform of the electromyogram of the expert in each phase

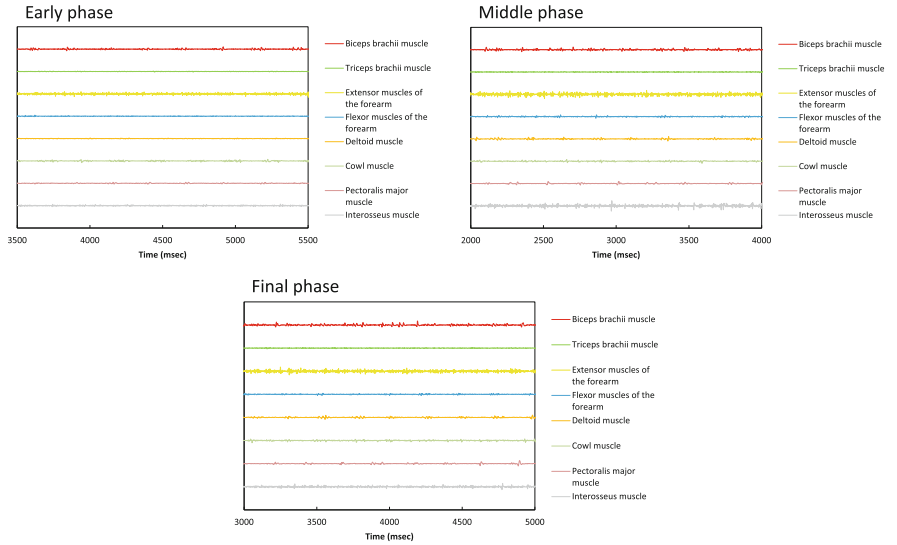

Fig. 9. Waveform of the electromyogram of the non-expert in each phase

As the results of smoothing waveform, there was so much of a difference among all phases. Constant muscle activities were shown in the polishing process. The biceps brachii muscle, triceps brachii muscle, extensor muscles of the forearm and interosseus muscle showed a high level of activities, flexor muscles of the forearm, deltoid muscle and cowl muscle showed a low level of activities. The pectoralis major muscle showed a middle level of activities. The smoothed waveforms of the biceps brachii muscle,

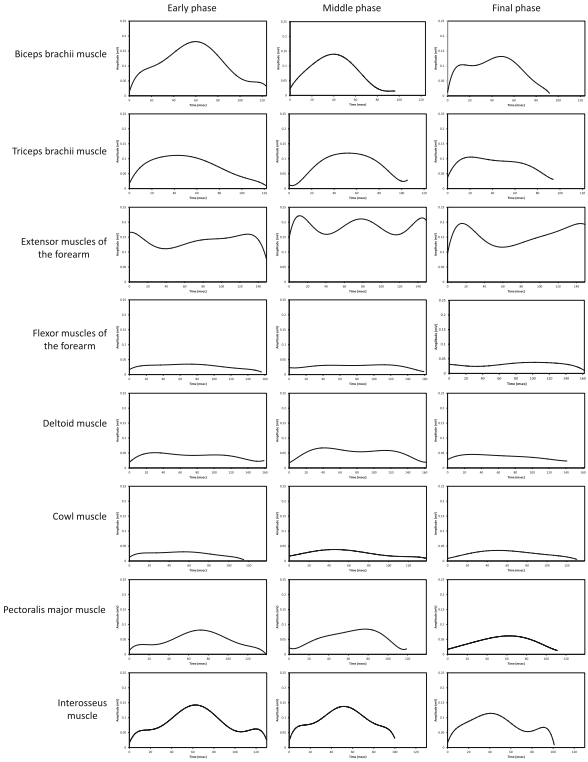

Fig. 10. Smoothed waveform of each muscle in the expert

triceps brachii muscle, pectoralis major muscle and interosseus muscle were shaped a chevron activities. The extensor muscles of the forearm showed a high level of sustained activity, and the flexor muscles of the forearm, deltoid muscle and cowl muscle showed a low level of sustained activities. The biceps brachii muscle, triceps brachii muscle, pectoralis major muscle and interosseus muscle showed high activities, and the extensor muscles of the forearm, deltoid muscle and cowl muscle showed low activities.

Muscles of the non-expert did not show the rhythmic activities. They showed the sustained arrhythmic activities. Muscle activity was increased in the second half of the polishing process. Especially, the activities of the biceps brachii muscle, extensor muscles of the forearm, pectoralis major muscle and interosseus muscle were increased in the final phase. On the other hand, the activities of the triceps brachii muscle and flexor muscles of the forearm were low. The activity of the deltoid muscle was increased from the middle phase, and it was high activity in the final phase. As the results of the smoothed waveforms, the muscle activity of non-expert was not constant like the expert.

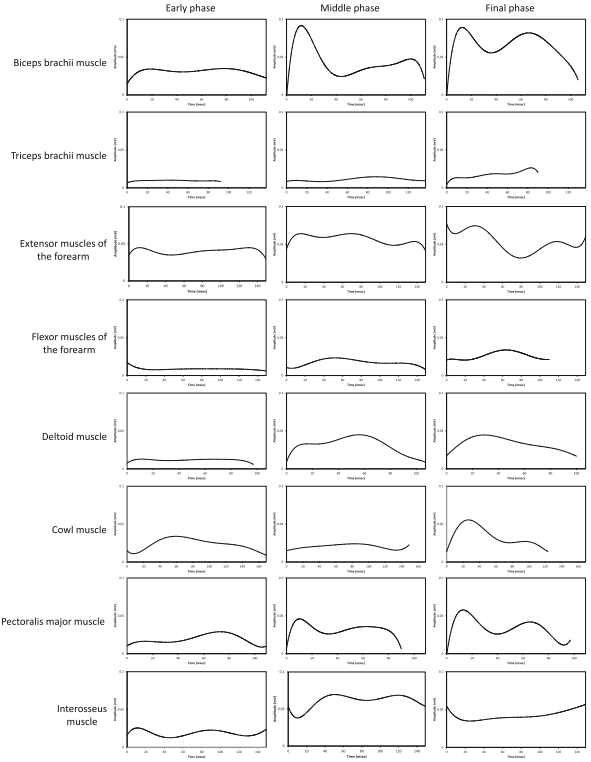

Fig. 11. Smoothed waveform of each muscle in the expert

4 Discussion

The specimen surface of the expert was more brightness than the one of the non-expert after polishing with the charcoal. There was not so much of a difference of gloss between the expert and the non-expert. Because the surface roughness was almost the same between the expert and the non-expert, an asperity of the specimen was not so much of difference. Therefore, the difference of gloss did not occur between the expert and the non-expert. As the result of the colorimetry, b* value of the expert was higher than the non-expert. Expert's specimen was more yellow than the non-expert. a* value of the expert was lower than the non-expert. Expert's specimen was less red than the non-expert. On the basis of these results, because the expert can polish the surface of Maki-e completely in the polishing process, the gold powder was seen on the Maki-e surface better than the non-expert. And then the expert specimen became more yellow. In addition to a scattering light from the asperity of the surface, the strong yellow derived from the gold powder was one of the factors that the specimen of the expert was more brightness than the non-expert.

As the result of the electromyogram, the muscles acted and relaxed repeatedly in the case of the expert because of the alternate action of an antagonistic muscle. Therefore

the expert does not increase the muscle activity, and he can polish the surface of the specimen without a muscle fatigue. It is good that we get physical activity with relaxed shoulder in any work. It seemed that the expert polished the specimen without the increased muscle activity in overall trend. The activities of the biceps brachii muscle, triceps brachii muscle, pectoralis major muscle and interosseus muscle were high. It is assumed that they were needed for the rhythmic activity of muscle in the polishing process. Most efficient muscle activity pattern was shown because other muscle activities were low, the shoulder was relaxed and the back muscle of the forearm was not often needed to grasp the object. In order to keep the motion stable for a long time, it is needed that the muscle activity is not increased, a laxity time is set for muscle, the oxygen is provided to the muscle and the forming an adenosine triphosphate (ATP) promoted. From a viewpoint of the physiological mechanism, it assumed that the muscle activity pattern of the expert is very efficient. This rhythmic muscle activity pattern is the greatest characteristic of the expert.

It seemed that the non-expert felt a muscle fatigue because muscle activity was needed in the final phase. An inefficiency of the action was shown in the case of the non-expert. The non-expert raised her upper limb and shoulder strongly. The opposite activity of the forearm muscle was shown between the expert and the non-expert. It seemed that the expert polished the specimen while a functional limbs of MP flexed position and IP extended position were kept in the palmarflexion. Non-expert used the outer muscle excessively while he took a tenodesis action with the wrist dorsiflexion. Therefor it seemed that the expert grasped the charcoal with each finger pad, the non-expert flexed the interpharangeal joint. The non-expert became difficult to polish the specimen rhythmical, and the muscle activity became arrhythmic. Muscle activity was too much inefficient in comparison with the expert. The non-expert polished the specimen while the shoulder blade was elevated by the action of the cowl muscle, the shoulder joint was turned outward by the action of the deltoid muscle, the elbow joint was inflected by the overactivity of the biceps brachii muscle and the wrist was dorsiflexed excessively. It seemed that the non-expert polished the specimen without extending the elbow joint because the triceps brachii muscle was the extensor muscle of the elbow joint. This was the reason that the activities of the triceps brachii muscle and flexor muscles of the forearm were low. It seemed that the activity of the flexor muscles of the forearm for the wrist palmar flexion was low because the wrist was dorsiflexed, and the outer muscle was performed in order to grasp the object.

It was found that the finish of the surface of Maki-e is made beautiful in the case of the expert because the rhythmic action does not cause the muscle fatigue, and the expert can polish the specimen by the constant force of the muscle.

5 Conclusion

As the results of this research, it was confirmed that;

- The expert's Maki-e specimen was more brightness and yellow than the non-expert.
- There was not much difference about the gloss and surface roughness between the expert and the non-expert.

- The expert took the rhythmic activity in each muscle. Therefore it seemed that the finish of the work became more beautiful.

These results suggest that how to use the body affects the finish of the Urushi crafts work in the polishing process. The non-expert can improve the finish of the work and the level of polishing skill by training the body position and motion like the expert.

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