




The Research of Cognitive Ergonomics in Surgery Instrument for Skin Stapler

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Abstract: In General surgery operation setting, to suture wound is a common skill. But this skill needs quite a long time to training and practice repeatedly. Therefore an innovation medical appliance, disposable skin stapler, was used to in place of tradition sutures task. 10 physicians and 10 nursing staffs in surgery field, 10 of non-medical occupations were selected for the research. First stage executes questionnaire interview. Second stage executes hand measure. Results demonstrated that: (1) The cognition of color in surgery medical staffs and non-medical staffs are the same. Red means danger, Yellow means warning and pay attention, Blue means indication. (2) For skin stapler, subjects wish this surgery instrument felt safety, second is practical, and then is stability and clean. (3) About " Pressing Trigger Upwards" icon, medical staff prefers to choose , non-medical one prefers to use . (4)  performs best to represent staples exit. (5) Via Chi square test three different groups show no significance in cognition of color and icon in skin stapler. The last stage of this research is to improve stapler type skin stapler according to the research results, and redesign a new skin stapler follow the cognitive ergonomic theory.

Key words: *Cognition, Ergonomics, Surgery Instrument, Skin stapler, Surgery.*

1. Introduction

In the domain of medical treatment, The Surgery always performs an important role. The physicians cure the patient through the operation into the body. However, The Surgery use lots of various instruments. They have to spend lots of time and efforts on the education training while facing to so much instruments. To match the operation work, it is very elaborate to prepare the instruments and raw materials to various operating process. Recently, the quickly developed surgical instruments are more suitable for manual manipulation and use. The skin stapler is an obvious example.

Skin stapler is a medical instrument that is similar to common staplers. The basic principle of skin stapler is mostly similar to that of common staplers. However, there are some distinctive detail designing in skin stapler: (1) Operating environment: skin stapler is an instrument for management of patients' surgical wounds in medical environment. (2) Operating method: Operation of skin stapler is to hold and stable the tool by using palms and thumb, respectively; and use the other 4 fingers to press the trigger and staple the staples into the epidermis. Instead using thumb and the index finger together to press the trigger and staple the staples into papers. (3) Structure: The skin stapler in this research is for single use only, therefore, the skin stapler can not be refilled with

new staples. However, the machinery is mostly similar to staple gun. (4) Material: The material of staple is the most distinctive part between common and skin staplers. Staple of skin stapler is made of special inert metal and therefore, no oxidation and rusting problems of the staple, as that of common iron-made staples, would be confronted [1], as shown in fig.1 &2 (D&G 35W Disposable skin stapler). There are two stages of surgical techniques training program for Resident Physicians in Teaching Hospital: primary stage and advanced training course. Use of skin stapler and learning of stapling techniques are scheduled in the primary training course.



Fig.1 D&G 35W Disposable skin stapler



Fig.2 Operation method of disposable skin stapler

Image recognition comes from the observation and inference of a certain image. The abstracts and organized ideas can then be applied. Norman (1993) presented people's image recognition by specific detail and conveyed the key points of image that is particularly noticed by people to strengthen the entire impressions towards image [2]. People manipulate manual tools according to their experiences, instead of the rules of their psychiatric recognition [3]. In other word, people manipulate manual tools by learning and acquired habits. Use of different manipulation methods depends on diverse knowledge and experience backgrounds. Therefore, physiological parameters, in addition to the recognition factors, should be considered in the designing of manual tools.

Barnes indicated that palmer flexion is the combination of the flexor action from radial side and ulner side, the action range is approximately 80° ~ 90° . Dorsal flexion is the extensor action from radial side and ulner side, the action range is approximately 50° . Ulnar deviation is the action of ulner side muscles, and the action range is approximately 60° , radial deviation is the action of radial side muscles with the action range approximately 30° [4]. Kwon recruited 419 subjects to conduct a cumulative trauma disorders, CTDs survey and found that 301 subjects experienced sickness or sore in at least one region. 29.1% and 28.9% of the subjects experience the sore episodes at evening and at night, respectively. Incidence of sore was highest in hospital workers, followed by housewives and laborers [5].

According to the research, the newly developed product skin stapler is frequently used in surgical environment. Therefore, this research wish to design better medical manual tools by studying skin stapler to understand and analyze the use and hand action of medical occupations while they are operating medical instruments. Our study focused on study of disadvantages and possible problems of skin stapler, including: poor skidproof and handle ergonomics design, etc. In addition, the research introduced the ergonomics concept into designing stage. Our study did great contribution to solve the systemic problems of "human-machine interface" through the investigation and analysis of cognitive ergonomics in the field of industrial designing. In addition to be used in surgery as mentioned in medical literature, skin stapler has two characteristics: quick and easy learning. However, most of these studies discussed efficiency and practicability from the surgical point of view without considering the products from designing aspect. Not even mention of the product study from personal factor viewpoint. This is the exact reason for our study to further investigate this medical manual tool.

2. Method

The delivery media of designed information, completely expression of designer's original idea and fit to users' recognition purpose are the key points of the entire information delivery system. Questionnaire design follows 19 principles[6].

2.1 Physical Characteristics of Hands

The 54 palm bones, including finger, palm and wrist bones, consist more than one-fourth of 206 bones in adults. Therefore, hands are very important parts for human. Kroemer[7] classified hand tool grip type to ten : (1) Finger Touch Without Holding. (2) Palm Touch Without Holding. (3) Holding or Pinching Grip. (4) Thumb-Finger Grip. (5) Thumb-Finger Palmar Grip. (6) Thumb-Forefinger Side Grip. (7) Thumb-Two-Finger Grip. (8) Thumb-Forefingers Enclosure. (9) Finger Palm Enclosure. (10) Power Grasp. 1-7 and 8-10 contact with small and big area, respectively. Operation of skin stapler should belong to power grasp. Our study investigated the physical strength of palms while holding and operating skin staplers. Therefore, the principles of newly designing were planned by measurement of static hand dimension and average holding strength.

2.2 Subjects and Experiment Procedure

Seventeen males and 13 females were recruited as subjects in this study. These subjects included 10 physicians, 10 nurses and 10 non-medical occupations from National Cheng Kung University Hospital Followings were the experimental protocol:

- (1) The entire process was recorded by digital camera, subjects were informed of the study purposes and measurement items.
- (2) Hand static measurement of subjects were measured by using Martin's instrument.
- (3) The average holding strength was calculated by the results of the third and fourth measurements of strength meter while the subjects were holding the strength meter.
- (4) Informed our subjects with the methods to fill out the questionnaire. Plenty of time was provided for the subjects to fill out the form.
- (5) Interview of subjects were implemented after the questionnaire was filled out.
- (6) Information was recorded and confirmed after the interview. Then the experiment is completed.

3. Results and Discussions

The research discuss about the result of experiment and Interview to Physicians and nurses.

3.1 Result of Survey




Chi Square Test was used to compare the difference among 3 subjects groups of physicians, nurses and others. No significant difference in color recognition, feeling towards skin stapler and recognition to tool labeling marks was observed in our results, as Table1.. Therefore, the above mentioned three subject groups can be considered as a single study group. Frequency statistics of users' color recognition was then analyzed (shows in Table2.): (1) blue stood for indication; (2) red stood for danger and (3) yellow stood for warning. Users' feeling towards skin stapler included (shows in Table3.): (1) safe, (2) practical, (3) stability, and (4) clean. Figure  and  can mostly represent the meaning of pressing trigger upwards, as Table4.. And figure , staples exit of skin stapler (shows in Table5.).

Table1. Chi Square Test

Recognition Item	χ^2	df	p
Indication	2.325	6	.888
Danger	1.071	2	.585
Warning	3.150	6	.150
Feeling	14.167	12	.290
Pressing trigger	12.754	12	.387
Staple exit	8.848	6	.182

Table2. Frequency of users' color recognition

Color Recognition	Red	Yellow	Orange	Green	Blue
Indication	2	2	0	10	16
Danger	28	2	0	0	0
Warning	8	15	3	4	0

Table3. Frequency of users' feeling towards skin stapler

	Safe	Practical	Clean	Stability	Beauty	Firm	Speed	Tech
Feeling towards skin stapler	9	7	4	6	2	1	1	0

Table4. Frequency of users' cognition of pressing trigger









								
Pressing trigger	9	9	3	3	2	2	2	0

Table5. Frequency of users' cognition of staple exit

						
Stapler Exit	12	7	5	5	1	0

3.2 Result of Anthropometry

The result of hand static anthropometry shows in Table6.

Table6. Result of hand static measurement

	Male		Female	
	Mean	SD	Mean	SD
Palm length	187.3	6.9	179.0	9.1
Palm width	87.8	5.8	76.3	2.5
Holding strength	33.5	3.2	21.3	4.2

3.3 Interview to Physicians and Nurses

Result shows as follow:

(a) Avoid direct touch of wounds and needles:

Needles are not used without suture. Using skin stapler to manage wounds can prevent physicians' hands from direct touching patients' wounds. Frequency of stabs and infection transmitted by needles can thus be greatly reduced in stapling.

(b) Simple and rapid operation:

Using skin stapler to manage wounds was 3~4 times more efficient than using suture. Notably, much more time can be saved by using skin stapler to manage longer wounds[8]. Only two steps are needed of using skin stapler to manage wounds: place skin stapler on wounds and press the trigger, that's it. Complicated wrist actions are needed in suture. More muscles and nerves are needed in suture from the viewpoint of biological dynamics. Additionally, actions of fingers and palms must be coordinated with wrist action.

(c) Easy learning of operational techniques:

Using suture to manage patients' wounds needs sophisticated techniques. The time needed for suture can be reduced when physicians become more skilled. However, it takes long time for physicians to learn the sophisticated suture techniques and reach certain technical levels. Besides, it's difficult for newcomers to be familiar with suture techniques due to the difficulty of clear expressing the details of diverse techniques by teaching staffs in the training process. On the contrary, use of skin stapler only requires simple steps. Newcomers can not only be familiar with the suture techniques shortly due to its easy learning nature but also operate the stapler skillfully after brief learning period.

(d) Not every body position is suitable to be managed by using skin stapler:

Skin stapler is not as widely used as suture. Skin stapler is mostly indicative for surgery of epidermis or subcutaneous tissues. It is not suitable for positions with larger tensions such as muscles that needs suture for wounds management. Besides, it is also not suitable for use in positions that is proximal to bones or with fewer muscles, such as fingers or wrists.

(e) Possible accidental breakdown:

Problems of skin stapler are mostly stuck of staples in the exit. The other more severe problem is: whole array of staples is possibly injected outwards while operating skin stapler due to poor designing or carelessly manual operation ! This can not be immediately repaired due to the sealing design of this disposable product.

(f) Poor personal factor handle designing:

The product in the present research can not be fully fitted to palms because it doesn't meet the contour of human palms. The designing is based on hand dimension of Westerners, therefore, its handle designing is not suitable for Orientals.

(g) The inert metal material of staples is not easy to induce allergy:

The staple is made of special compound metal. The part of staple that touches subcutaneous tissue is made of inert metal which inert chemical nature is not easy to induce skin allergy. On the contrary, the thread of suture is easy to interact with epithelial or subcutaneous tissues and lead to sickness or allergy.

(h) The staple will not press skin to form scars:

The principle of using suture to manage wounds is to pull and fix bilateral skin around the wound together by using the tension of thread. The thread must be pulled very tightly, therefore, the tightly-pulled thread will transmit pressure onto skin and lead to chilopod-like scar formation. However, the metal staple is not easy to be deformed and will not transmit pressure onto skin to result in scar formation.

(i) Patients will feel more painful when staple is taken out than taking out stitches:

Patients subjectively think that they feel more painful when the staple is taken out, compare with taking out stitches. According to physicians, this is possibly due to patients' psychological response or the incomplete fit of the angles for stapling and taking out staple. Therefore, the staples, taken out from another direction, can

thus scrape the surrounding nerves and muscles to result in pain.

4. Ergonomic Design of Skin Stapler

A conceptual prototype is usually appeared in designers' mind when they are designing product interface. Designers can indirectly convey their thinking to make users understand through the expression of product interface. To make the distance between designers' and users' conceptual prototype becomes closer is the importance of recognition designing.





4.1 Design Principles

The designing principles for skin stapler, from the viewpoint of recognition personal factor, are as followings:

(a) Holding method that conform to anthropometry:

The research suggest to design the holding method that is suitable for the hand action of Orientals by using the data of Oriental physiological measures and improve the disadvantage of unsuitableness of the present product. Flexion of the finger at the proximal interphalangeal (PIP) joint averaging 100 degrees or more, and distal interphalangeal (DIP) joint averaging 90°. Wrist joint Ulnar Deviation is 37.7°; Radial Deviation 21.1° [9]. The modeling of skin stapler in our study was designed according to anthropometrical hand contour. Hopefully, can accomplish the purposes of completely fit of skin stapler to hand contour and conveniently manipulation.

(b) Clear and definite labeling:

The designing principle was based on the experimental results of our questionnaire: Using blue, red and yellow to stand for indication, danger and warning respectively. Besides, using figure  and  to stand for the meaning of pressing while manipulating the skin stapler. However, finally decided to use figure  because this figure showed timing and mobile factors which can indicate the process of holding and pressing. Figure  is chosen to stand for the meaning of staple exit.

(c) Feeling of safe, particle, stable and clean:

Using streamline shape curve and light gray the express the above mentioned feelings.

(d) skidproof effect designing:

According to our interview, the research found that skin stapler is easy to slip off from palms due to the inefficient skidproof effect. Therefore, hope that our designing of using "soft lump-line rubber material" in the appearance of skin stapler can meet the purpose of skidproof.

4.2 Prototype



Fig.3 The form of skin stapler



Fig.4 Operation method of skin stapler

5. Conclusion

A survey for the study of surgical environment in National Cheng Kung University Hospital was conducted. No significant difference in the color and image recognition was found between medical and non-medical occupations through interviewing with medical occupations and conducting survey form the viewpoint of recognition personal factor. Besides, the research proposed redesigning principles and novel model of skin stapler according to our result of interview and survey. However, this novel designing can not be tested because the model has not been commercially manufactured.

Hopefully, recognition personal factor designing principles and physiological measurements proposed by our study can provide reference for the future designing of skin stapler.

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