Effectiveness of Rotating Stringer in Sterilization Process

Natthacha Chiannilkulchai, Peinjit Bhumisirikul*

Abstract: One of the major problems of the surgical instruments in steam sterilization is having instruments in a locked position. This is where the tips are not separated from each other and steam cannot contact all surfaces of the instruments. Although the various types of surgical stringers are used to hold the surgical instruments in an open position, they differ in locking designs and are inconvenient to lock and release stringers in the sterile containers. To overcome these limitations, this study aimed to design and develop an innovative Rotating Stringer, a new locking system, and evaluate its efficacy. The study design follows the steam sterilization guideline that the tips must be separated by using a rotating mechanism to design the new locking system. For the efficacy evaluation, purposive sampling was with 45 Thai perioperative nurses in Ramathibodi Hospital, Bangkok, Thailand who examined the Rotating Stringer in sterile instrument containers for five surgeries. At the end of the fifth use, they were asked to complete the Rotating Stringer Problem Record and the Rotating Stringer Effectiveness Scale which were used to test the structural design and function of the Rotating Stringer. The data collected from February to May 2019. Descriptive statistics were then used to analyze the data.

Results indicated that there were no problems reported in the use of the Rotating Stringer in 135 different surgeries. According to all participants' opinions, the overall effectiveness of the instrument was highly rated on function, usability, and safety. The Rotating Stringer regulates the instrument tips in separation following sterilization guidelines for patient safety. It is convenient to use in a sterile container and protects wrist injury. The Rotating Stringer has now been patented for use in practice.

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Introduction

Surgical instruments and medical devices used in a sterile field during surgical procedures or in contact with the inner areas of the body must be sterile.[1,2] It is the responsibility of healthcare personnel not only to cure diseases of the patients but also to prevent transmission of diseases.[2] If contaminated surgical instruments are used, severe infection may occur.[1] The process used to sterilize metal surgical instruments before use in surgery is steam sterilization, also known as 'autoclave'.[3] The surgical instruments are of various kinds and types that are collected in a group by type and tip direction is called the 'instrument set'.

According to the guidelines for steam sterilization, the surgical instruments must be placed in a mesh container or a specially designed container and then placed in the rigid container so that steam can easily penetrate and remove/inhibit microorganism relocation and contamination.[4] To distribute steam throughout all parts of the surgical instruments with ring-handles, they must be in an unlocked position and the tips are separated in the open position.[3, 5] In developing countries, especially Thailand, the typical instruments for arranging the surgical instruments with ring-handles in a group for steam sterilization include a safety pin holder and sponge holder. The design of a safety pin holder does not conform to the regulation of the need for surgical instruments to be in an unlocked position and the tips are separated away from each other. Sponge holders can be used to arrange the surgical instruments in a group in an unlocked position by inserting two sponge holders through ring-handles of the surgical instruments on the opposite side. Even though the surgical instruments are in an unlocked position in this scenario, they have similar tip separation problems. Therefore, both methods cannot ensure that the surgical instruments remain in an unlocked position and maintain the tips separation follow the guidelines for steam sterilization.

The regulated instrument used to organize the surgical instruments in the open position is known as a 'stringer'. Different types of surgical stringers differ in locking designs and are inconvenient to unlock in a sterile container.[6] Thus there is a need to improve the design of the surgical stringer to prevent the infection following the guidelines for steam sterilization, and so that it is convenient to keep and release surgical instruments in the place that they were located. The new design of our Rotating Stringer is a rectangular shape, made of stainless steel, designed to be used with ring-handled instruments, and to maintain the separation of the surgical tips at least 1 mm apart. The locking system is composed of a locking headpin and a hook-locking socket, which used a rotating mechanism to lock and unlock the stringer in the sterilization container.

Literature Review

The typical features of previous surgical instrument stringers use U-shaped parallel rods to maintain and regulate the surgical instruments in a group, however, they are different in closing or locking system, including Ball & Socket,[7] Spring Lock[8], Pin Lock Stringer[9], Center Lock[10], and U shaped[11] as shown in Figure 1 below:

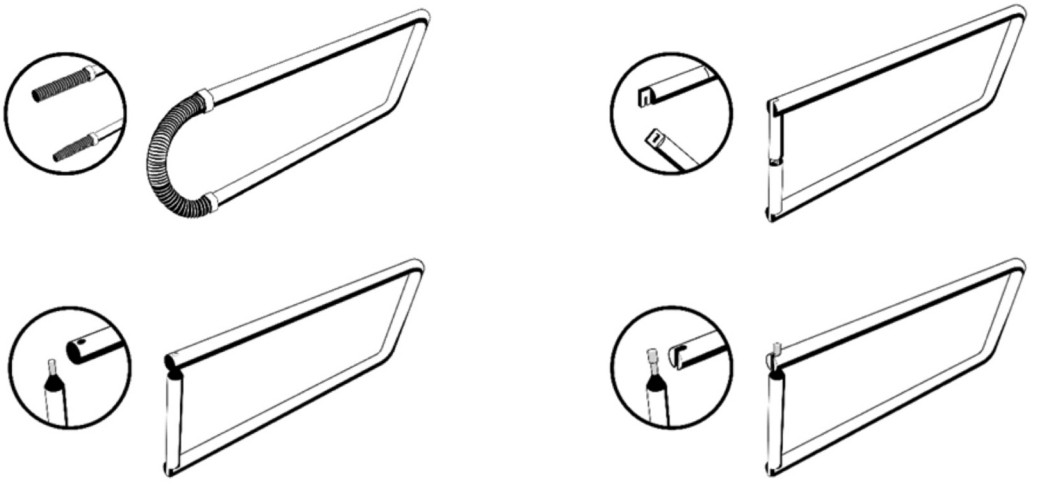

Figure 1 Locking features of other commercial stringers

In the use of a range of stringers, their designs and user requirements tended to focus on three issues. First, some imported stringers can keep surgical instruments unlocked in an open position as specified, but the surgical instruments are compressed the ratchet is engaged and their tips become stuck together because the length between the inner sides of the ring handles with ratchets unengaged is 70–71 mm. This length is longer than the length of the wide side of most prior stringers (63–70 mm). A stringer should be wide enough to maintain the surgical instrument tips separately in a sterile container.[6] For a stringer to keep the tips of surgical instruments separated, the wide side must be longer than 70 mm. Second, some designs of stringers are difficult to hold and to release the surgical instruments inside the container during surgical preparation and more time is needed to take and release the surgical instruments outside the container; this is inconvenient, especially in rush hours and emergency cases.[12] Third, some stringers need more force to push and pull the locking headpin in and out of the small hole to lock and unlock the stringer. This greater force may cause nurses' wrist injuries through a twisting action. Furthermore, the cost of a commercial surgical instrument stringer is more expensive compared to the cost of the new stringer designed in this study. Thus, the way to overcome the limitations of prior stringers was to design a new surgical instrument stringer for holding the surgical instruments and to overcome the problems mentioned above.

Purpose of the Study: The objective was to design and develop the Rotating Stringer for holding the surgical instruments in an unlocked position and with the tips separated, and to evaluate the effectiveness of this.

Methods

Study design: A design and development research process was conducted to develop the Rotating Stringer and to evaluate its effectiveness. This overall approach is usually used to guide the development of medical devices.[13] The details of each phase are as follows:

1. Design and development

1.1 Review and analysis of the problems associated with available stringers took place in the Institute by the principal investigator (PI) and the research team. This resulted in an agreement to develop a new stringer.

1.2 Design and development of the Rotating Stringer followed the steam sterilization guideline[3–5] in that surgical instruments are in an open position and the tips are separated, and that stringer can be opened and closed easily in the sterile container. The present design evolved from the prior designs that are U-shaped, but it has a modified locking system. The design comprises 1) The length of upper and lower rods are 160 mm; 2) The wide side of the stringer is 73 mm which is sufficient to maintain the surgical instruments in the unlocked position and to separate the tips in open position; 3) The corners of the surgical stringer (upper and lower) were designed as rounded corners; 4) The locking rod is 72.60 mm long. It can rotate in a perpendicular arc on a pivot joint at the lower-left corner; 5) The locking headpin is placed at the top of the locking rod (height = 6.10 mm and diameter = 2.00 mm) as shown in Figure 2; and 6) The hook-locking socket at the left end of the upper rod (front groove width = 3.10 mm, height = 1.70 mm, length 3.90 mm, and socket wide 2.45 mm), as shown in Figure 3.

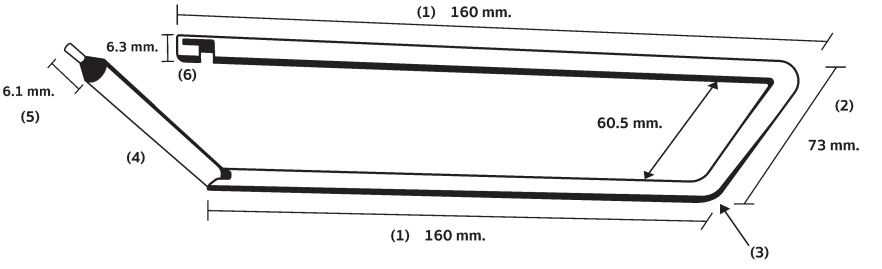

Figure 2 First design model of the Rotating Stringer

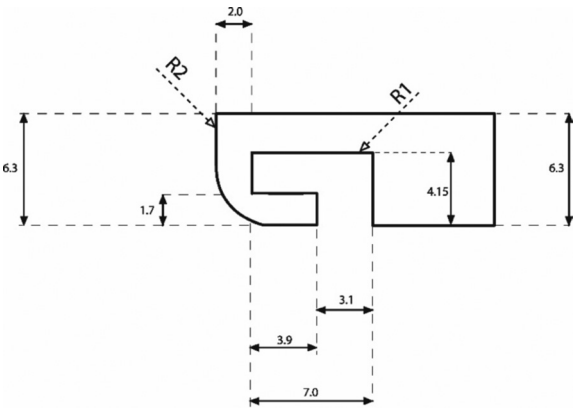

Figure 3 First design of the hook-locking socket

1.3 Selection of materials to construct the Rotating Stringer included a 6.3 mm diameter 316 L stainless steel rod, which is a type of marine stainless steel and is used to make biomedical implants.[14]

1.4 Completion of the design and development process described in section 1.2.

1.5 A pilot test was conducted with ten perioperative nurses from Sirikit Medical Center and Orthopedics Operating theatre in Ramathibodi Hospital who were excluded from the main study sample. After the pilot test, four nurses reported that they had difficulty moving the locking headpin in and out of the hook-locking socket as well. As a result, the square corners of the hook-locking socket were changed to rounded corners, and the inner side of it was changed to a semicircular shape. These changes reduced the outside length of the hook-locking socket from 6.3 to 5.9 mm, so that it made the locking headpin more conveniently rotate in and out of the hook-locking socket, as shown in Figure 4. Two nurses reported that the Rotating Stringer cannot regulate the surgical instruments with a length between inner sides of ring-handles at more than 73 mm (such as right-angle being in ratchet engaged, the length is 77 mm) in the open position. So, the instrument tips were in a locked position. Therefore, the width was increased and the Rotating Stringer was produced in two sizes, 73 mm and 88 mm. One nurse reported that the Rotating Stringer unlocked itself before being used. As a result, the locking headpin diameter was increased from 2 mm to 2.15 mm to make it fit securely in a hook-locking socket. The new design of the Rotating Stringer is shown in Figure 5.

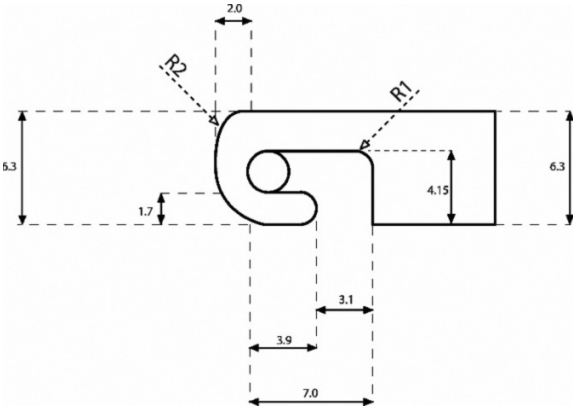

Figure 4 Second design of the hook-locking socket

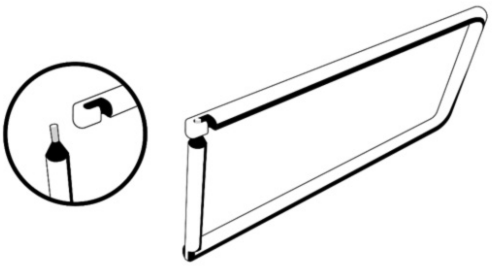

Figure 5 Final design of the Rotating Stringer

2. Efficacy evaluation

Evaluation of the effectiveness of the Rotating Stringer for patient safety included assessments of the problems in using the Rotating Stringer to set up the instruments used for surgery and to evaluate the perioperative nurses' opinions regarding the use of the Rotating Stringer.

Sample and setting: The sample was 45 perioperative nurses who were selected by purposive sampling and working at the surgical department, in the Main Building of Ramathibodi Hospital, Bangkok, Thailand. This hospital was selected because all surgical instrument sets are contained in standard containers for steam sterilization and were appropriate to evaluate the effectiveness of the Rotating Stringer. All participants had one year of experience as perioperative nurses and had used the Rotating Stringer in preparing major sets of surgical instruments five times for surgery were included in the study. All the 45 nurses stated their willingness to take part in this study.

Instruments

1. The Rotating Stringer Problem Record was developed by PI. This record consisted of six items, used to test the structural design of Rotating Stringer in terms of whether it functions properly. An example item is "the locking headpin is sticky and is difficult to rotate out of the locking socket, possibly causing a wrist injury." The rating scale has two points of measurement to score: rate 1 (if they found a problem) or rate 0 (if they did not find a problem). The Rotating Stringer Problem Record was reviewed and validated by three experts: two head nurses from two perioperative units and one infectious nursing instructor.

2. The Rotating Stringer Effectiveness Scale based on the nurses' opinions regarding the use of the Rotating Stringer was developed by the PI. The Effectiveness Scale contains 12 items to measure three main subscales: functions of the Rotating Stringer, usability of the Rotating Stringer, and safety of using the Rotating Stringer. Each item is answered on a 5-point Likert scale, ranging from 1 (very ineffective) to 5 (very effective); higher scores are associated with greater effectiveness. The instrument's content validity was determined by a panel of three experts, and the CVI of the 12 items was 0.90. One item in the function subscale had the same meaning in the usability subscale, and were grouped in the usability subscale. Thus, the remaining 11 items were used to determine the internal consistency reliability based on 10 pilot perioperative nurses' opinions (Cronbach's alpha was 0.92). The overall Cronbach's alpha coefficient of the instrument after assessment by all 45 perioperative nurses was 0.918. To determine the inter-item correlation among these three subscales Cronbach's alpha was used.[15,16] The subscales showed a Cronbach's alpha of 0.76 for the function subscale, 0.85 for the usability subscale, and 0.82 for the safety subscale. Therefore, these three subscales were analyzed as being an interval scale.[17] A three cut-point score for a 5-point Likert scale was used (Maximum − Minimum) / Group = (5-1)/3 =1.33; the mean score 1.00 to 2.33 indicates low effectiveness, 2.34 to 3.66 indicates moderate effectiveness, and 3.67 to 5 indicates high effectiveness.[18,19]

Ethical considerations: The Human Research Ethics Committee, Faculty of Medicine Ramathibodi Hospital, Mahidol University approved this study (IRB no. MURA 2018/902). Each participant received pertinent information, including the purpose of the study, data collection, potential to withdraw from the study without any consequence to their work, and confidentiality and privacy of the participants. A member of the research team began data collection after the participants provided written consent.

Procedure for preparing the surgical instruments: Many kinds of surgical instruments used for surgery are grouped in the form of an instrument set. The instrument set used for evaluating the Rotating Stringers was called Major Set. The researchers used 20 Major Sets in this study. For preparing this, the researchers trained the staff in the Central Sterile Supply Department to use the Rotating Stringers for regulating the surgical instruments in the containers for steam sterilization. The process for preparing the surgical instruments in the containers for steam sterilization was as follows.

Using two Rotating Stringers sizes 73 x 160 mm for the surgical instruments with the length between the inner rim of both ring-handle being less than 70 mm, and size 88 x 160 mm for the length between the inner rim of both ring-handle being more than 73 mm and verifying that the used stringer met the ring-handle spacing as defined; and

Then, seven steam chemical integrator stripes class IV (integrating indicator) were placed at the ends of the instrument tips along the line with Rotating Stringer to ensure that the steam can contact the entire surface of the tips before putting the instrument set through the sterilization process.[5]

Data collection: The researchers met with the participants in a group to explain how to use the Rotating Stringer and ask for their cooperation. The participants were informed to examine the color of the steam chemical integrator stripes and lift the Rotating Stringers when they opened the Major Set. The stripes are meant to turn black from the reject area to the accept area, to indicate that the steam contacts the entire surface of the instrument tips. Another factor is that the stripes can pass through the instrument tips when the stringers were lifted, which means the instrument tips are separated. Every day one researcher checked which surgery used the Major Set and after the surgery finished, the name of scrub and circulating nurse who examined the Rotating Stringers together were recorded. The participants who examined the Rotating Stringers in Major Set for five times (surgeries) were approached. At the end of the fifth time in using Rotating Stringer, the participants were asked to complete the Rotating Stringer Problem Record and the Rotating Stringer Effectiveness Scale. The time to complete the measurements for each participant around 15-20 minutes. The 45 participants needed to examine the Rotating Stringers in a Major Set at least 113 cases (one surgery examined the Rotating Stringers by two persons; 45 persons x 5 cases/person = 225 cases, one surgery is recorded by 2 persons = 225/2 = 113 cases at least). Data were collected from February to May 2019.

Data analysis: The data were screened before analysis. Descriptive statistics, including frequencies and percentages, were used to analyze the data and identify problems in using the Rotating Stringer. The Rotating Stringer Effectiveness Scale was analyzed in two parts. First, the overall items and the subscales assumed as an interval scale were analyzed as a group by using means and standard deviations.[15, 16] Second, the individual items being an ordinal scale were analyzed by using the medians and frequencies to measure central tendency and dispersion.[16]

Results

From February to May 2019, all 45 participants used the Rotating Stringer in Major Sets for 135 surgeries. The data showed that there was no incidence of the locking headpin being stuck and/or difficult to

rotate in and out of the locking socket, possibly causing a wrist injury; no record of the pointed end of the locking headpin being too sharp, making it dangerous for the user; no problem with the front groove of the hook locking socket being too narrow, making it difficult to rotate the locking headpin in and rotate it out; no record of the front groove of the hook locking socket being too wide, causing the locking headpin to come out of the hook locking socket before actual unlocking; no report that the surgical instruments being in engaged ratchet; and the tips being in the lockable position. However, one participant reported that the locking rod stacked, and the pivot joint was sticky, restraining locking rod movement within its perpendicular arc.

The mean score for the evaluation of all the items was 4.70 ± 0.38 (**Table 1**). Mean scores higher than 4 points were computed from the analysis of all three subscales. The subscale scores were: 4.77 ± 0.41 for the functions of the Rotating Stringer, 4.65 ± 0.44 for the usability of the Rotating Stringer, and 4.72 ± 0.39 for the safety of using the Rotating Stringer. Most nurses (n =27, 60%) assigned 5 points to all items (median = 5 points), indicating that the Rotating Stringer was highly effective. All the 945 chemical integrator stripes turned to black from the reject area to the accept area, and all stripes were able to be passed through the tips of the surgical instruments.

Table 1 Participants' Opinions of the Rotating Stringer (N = 45)

Variables	Min	Max	Median	n (%)	M±SD	Level of Effectiveness
Functions of the Rotating Stringer.					**4.77±0.41**	**High**
The Rotating Stringer holds the instrument tips in an open position. This allows the steam chemical integrator stripes to be inserted between the instrument tips	3	5	5	35 (77.80)		
The Rotating Stringer ensures that the steam sterilized the entire surface of the instrument tips. The steam chemical integrator stripes turns to black color from the rejected to the accepted area.	4	5	5	35 (77.80)		
Usability of the Rotating Stringer					**4.65±0.44**	**High**
The pivot joint connecting the locking rod with the lower rod allows the locking rod to be removed easily within its perpendicular arc.	3	5	5	27 (60.00)		
The locking headpin has a smooth surface, which reduces the force needed to rotate it in and rotate it out of the hook-locking socket.	3	5	5	28 (62.20)		
The hook-locking socket appropriate in size and shape for the locking headpin which makes it easier to arrange the surgical instruments in the Rotating Stringer	3	5	5	33 (73.30)		
The smoothness of the upper and lower rods make it easier to insert them through the ring-handles of the surgical instruments	4	5	5	32 (71.1)		
The size and shape of the locking headpin fit for hook-locking socket made it security before unlocking	3	5	5	36 (80.00)		

Table 1 Participants' Opinions of the Rotating Stringer (N = 45) (Cont.)

Variables	Min	Max	Median	n (%)	M±SD	Level of Effectiveness
Safety in using the Rotating Stringer					**4.72±0.39**	**High**
The smooth surface of the Rotating Stringer minimizes the possibility of the nurse's glove being torn.	4	5	5	33 (73.30)		
The Rotating Stringer is made of stainless steel, and its surface and shape are unaffected by steam sterilization.	4	5	5	37 (82.20)		
The Rotating Stringer has a surface that is smooth and slippery and does not scratch the surface of the surgical instruments when they are slid on the Rotating Stringer.	4	5	5	35 (77.80)		
Rotating the locking headpin in and out of the locking socket requires little force and thus prevents wrist injuries.	3	5	5	27 (60.00)		
Total					**4.70±0.38**	**High**

Note. 1) SD = standard deviation;
2) n = number of participants who rated the item with the median score.

Discussion

Functions: The participants rated items and the subscale regarding the functions of the Rotating Stringer as being highly effective. These scores indicated that the Rotating Stringer maintains the instrument tips in the open position and separated. It can be explained that the Rotating Stringer was designed in two sizes, including 73 mm and 88 mm, to accommodate different sizes of surgical instruments with the same degree for control instrument tips separately (Figure 6). Also, confirmation of the instrument tips was contacted fully with steam and separately done by placing chemical integrator stripes between the instrument tips, which were all in black and passed through the tips. The chemical integrator stripes turned to black from the reject to the accept area, meaning the steam was penetrated and contacted the entire surface of the tips and ensured that the surgical instruments were fully sterilized.[20] The stripes were passed through the tips indicating that the distance between the tips was separated at least 1 mm and safe for use in surgery.[20, 21] Improper reprocessed surgical instruments can be used in many operations that may lead to potential infection in a large number of patients if they are contaminated.[22, 23]

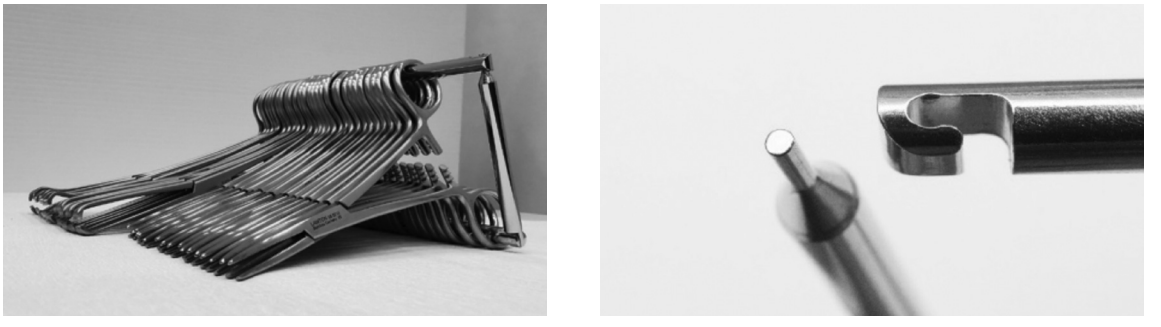

Figure 6 The Rotating Stringer holds surgical instruments in an open position and separates the tips

Usability: Regarding the aspect of usability, the Rotating Stringer had a high degree of effectiveness. The locking system of Rotating Stringer is called a rotating mechanism because it is composed of the locking headpin and the hook-locking socket. The locking headpin has a round and smooth surface and outside of the hook-locking socket is a semicircular shape that makes the locking headpin of the locking system easy to rotate in and out of the hook-locking socket and difference from other commercial stringers. The shape and rotating mechanism of the Rotating Stringer both contributed to the ease of use to secure and release the surgical instruments in their sterile container as shown in Figure 7, and this is contrasted to the locking system of imported stringer that can secure and release the surgical instruments in the same container.[24]

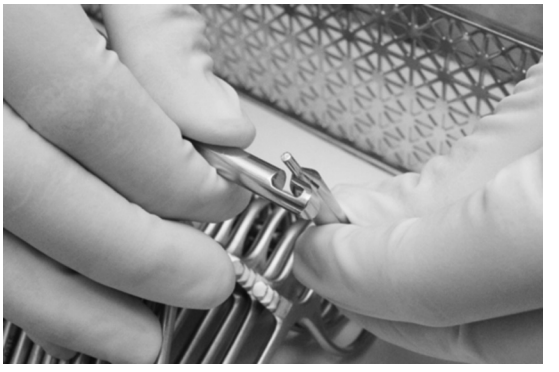

Figure 7. Securing and releasing the Rotating Stringer in the sterile container

The hook-locking socket has a thickness of 1.7 mm, 3.9 mm long, and 2.45 mm wide, appropriated with the 2.15 mm locking headpin diameter. If the diameter of the locking headpin is too small, this makes it easy to loosen and the fit in the locking socket is insecure. On the other hand, if the locking socket is too small, it is difficult to rotate the locking headpin in and out. Therefore, the size and shape of the locking headpin fit for the hook-locking socket make it secure before unlocking.

The wide sides of the Rotating Stringer are 73 mm, and 88 mm, wide enough to keep the surgical instruments unlocked in the open position and the surgical instruments cannot be compressed to lock. This feature makes the Rotating Stringer different from other imported stringers. The length of the long side is 160 mm, which is appropriate to arrange the grouped instruments in the proper sequence. The surface of Rotating Stringer is smooth, and the diameter of the upper, lower, and locking rods is only 6.3 mm compared to the diameter of ring-handles of surgical instruments (wide side) being 20 mm that allows the rods to be easily inserted through both ring-handles of the surgical instruments. This means that the Rotating Stringer can be used to conveniently place the surgical instruments in the proper order for surgery.

The pivot joint between the lower rod and the locking rod allows the locking rod to be parallel with the upper rod, which makes it easier and convenient to insert these rods through both ring-handles. However, one participant noted in her problem record that the pivot joint was sticky, so it was difficult to move the locking rod to the axis of the lower rod. The result from the evaluation showed that the pivot joint was deformed because of heavy pressure being applied on the top of the stringer. However, this problem may have been caused by the stringer design, as mention in the evaluation of the usability of medical device development.[25] The resolution of this crucial issue requires additional information obtained in a clinical setting.

Safety: Regarding the aspect of safety, the Rotating Stringer scored high effectiveness. The results indicated that the Rotating Stringer has a smooth surface and the cylindrical rod shape so that it does not cause glove tears and when the stringer rods are inserted through the ring-handles, they do not cause the instruments to be scratched or damaged, consistent with the design of other surgical stringers, which have a round rod shape.[8, 11, 26] Additionally, a Rotating Stringer made of 316L stainless steel can enter into the steam sterilization process without losing its shape or rusting. Stainless steel 316L is a standard material used to produce medical devices for steam sterilization, has improved corrosion resistance, and does not degrade significantly.[14, 27] This indicates the material used to produce the Rotating Stringer is standard material and safe for use in steam sterilization. To hold the surgical instruments in the Rotating Stringer, a rotating mechanism was used to rotate the locking headpin in and out of the hook-locking socket that requires less wrist force and more protection against wrist injury. This feature is different from other imported surgical stringers.

Conclusions and Implications for Nursing Practice

The Rotating Stringer keeps the surgical instruments in an open position, maintains their instrument tips separation, and allows steam to make contact with the entire surface of the surgical instruments. The use of this Rotating Stringer also makes it convenient for perioperative nurses to count and arrange the order of surgical instruments, which will promote patient safety. In this study, a problem reporting record was used to describe nurses' difficulties and concerns to provide their opinions, allowing us to identify possible design errors and evaluate the effectiveness of the Rotating Stringer. This study showed that if the length between the inner sides of the ring-handles with ratchets unengaged was 85 mm, the wide side of the Rotating Stringer should be more than 85 mm. Accordingly, as researchers we intend to design the Rotating Stringer in different sizes so that it can be used with different types and sizes of surgical instruments. Mahidol University, Thailand received Patent No 1703001679 on May 10, 2018, for the Rotating Stringer. In a further development, the authors intend to develop a device for holding sharp instruments separation that can be sterilized by steam.

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ประสิทธิผลของอุปกรณ์ร้อยเครื่องมือผ่าตัดแบบสองทางในขั้นตอนการทำให้ปราศจากเชื้อ

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บทคัดย่อ: ปัญหาสำคัญประการหนึ่งของการทำให้เครื่องมือผ่าตัดปราศจากเชื้อด้วยไอน้ำ คือ เครื่องมืออยู่ในสภาพที่ถูกล็อค และส่วนปลายของเครื่องมือ คือ บริเวณที่ใช้งานไม่เปิดอ้าแยกออกจากกัน ทำให้ไอน้ำไม่สามารถผ่านผิวสัมผัสของเครื่องมือได้ทั่วถึง ปัจจุบันแม้ว่าจะมีอุปกรณ์ร้อยเครื่องมือผ่าตัดที่สามารถกำหนดให้เครื่องมือผ่าตัดอยู่ในสภาพคลายล็อคและปลายของเครื่องมือแยกออกจากกันได้ แต่อุปกรณ์ร้อยเครื่องมือผ่าตัดเหล่านี้มีระบบการล็อคและการใช้งานที่แตกต่างกัน และบางรุ่นไม่สะดวกในการล็อคและปลดล็อคภายในเซ็ตเครื่องมือผ่าตัดปราศจากเชื้อ เพื่อปรับแก้ข้อจำกัดที่เกิดขึ้นการศึกษานี้จึงมีวัตถุประสงค์เพื่อออกแบบและพัฒนานวัตกรรมอุปกรณ์ร้อยเครื่องมือผ่าตัดแบบสองทาง โดยใช้กลไกการหมุนทำเป็นระบบล็อคแบบใหม่ และเพื่อประเมินประสิทธิภาพของอุปกรณ์ร้อยเครื่องมือผ่าตัดแบบสองทางที่พัฒนาขึ้น การออกแบบอุปกรณ์ร้อยเครื่องมือผ่าตัด เป็นไปตามแนวทางของการทำให้ปราศจากเชื้อด้วยไอน้ำคือปลายของเครื่องมือผ่าตัดต้องเปิดอ้าและแยกออกจากกันโดยใช้กลไกการหมุน สำหรับการประเมินประสิทธิภาพใช้การเลือกกลุ่มตัวอย่างแบบเฉพาะเจาะจงเป็นพยาบาลห้องผ่าตัดของไทยจำนวน 45 คน ในโรงพยาบาลรามาธิบดี กรุงเทพมหานคร ประเทศไทย ผู้ตรวจสอบอุปกรณ์ร้อยเครื่องมือผ่าตัดแบบสองทางภายในเซ็ตเครื่องมือผ่าตัดปราศจากเชื้อที่กำหนดไว้ในการผ่าตัดครบ 5 ครั้ง ในตอนท้ายของการใช้งานครั้งที่ห้าพยาบาลห้องผ่าตัดผู้ตรวจสอบอุปกรณ์ร้อยเครื่องมือผ่าตัดแบบสองทาง จะถูกขอให้ทำแบบบันทึกปัญหาจากการใช้อุปกรณ์ร้อยเครื่องมือผ่าตัดแบบสองทาง และแบบวัดประสิทธิภาพการใช้อุปกรณ์ร้อยเครื่องมือผ่าตัดแบบสองทาง ซึ่งเป็นแบบทดสอบด้านการออกแบบโครงสร้างและการทำงานของอุปกรณ์ร้อยเครื่องมือผ่าตัดแบบสองทาง เก็บรวบรวมข้อมูลตั้งแต่เดือน กุมภาพันธ์ ถึง พฤษภาคม พ.ศ. 2562 จากนั้นใช้สถิติเชิงพรรณนาในการวิเคราะห์ข้อมูล

ผลลัพธ์พบว่า จากบันทึกปัญหาในการใช้งานอุปกรณ์ร้อยเครื่องผ่าตัดแบบสองทางในการผ่าตัดจำนวน 135 ราย ไม่พบปัญหาจากการใช้งาน จากการประเมินคิดเห็นของผู้เข้าร่วมโครงการทั้งหมดให้คะแนนประเมินประสิทธิภาพโดยรวมของอุปกรณ์ร้อยเครื่องมือผ่าตัดแบบสองทางเฉลี่ยอยู่ในระดับมีประสิทธิภาพสูงทั้งสามด้าน คือ ด้านการทำหน้าที่ การใช้งาน และความปลอดภัย อุปกรณ์ร้อยเครื่องมือผ่าตัดแบบสองทางกำหนดให้เครื่องมือผ่าตัดคลายล็อคและปลายของเครื่องมือผ่าตัดแยกออกจากกันตามแนวทางการของการทำให้ปราศจากเชื้อด้วยไอน้ำเพื่อความปลอดภัยของผู้ป่วย อุปกรณ์ร้อยเครื่องมือผ่าตัดแบบสองทางเป็นเครื่องมือที่สะดวกใช้ภายในเซ็ตเครื่องมือผ่าตัดปราศจากเชื้อและป้องกันการบาดเจ็บที่ข้อมือ อุปกรณ์ร้อยเครื่องมือผ่าตัดแบบสองทางได้รับการจดสิทธิบัตรสำหรับการใช้งานในทางปฏิบัติ

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