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A COMPARATIVE STUDY OF INNOVATIVE NEEDLE HOLDER WITH BETTER ERGONOMICS VS CONVENTIONAL NEEDLE HOLDER FOR OPEN SURGERY

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ABSTRACT
Standard ring-handled needle holders can cause hand fatigue, wrist discomfort, and reduced suturing efficiency during prolonged use. A modified ergonomic needle holder was designed and fabricated for open surgical suturing by retaining the conventional serrated jaws and shank while replacing the circular finger rings with elongated rectangular handles and incorporating a centrally positioned locking mechanism. The modified configuration was developed to facilitate palming, distribute force across a broader area of the hand, reduce repetitive finger movements, and improve ergonomics during open surgical suturing. This prospective, comparative, analytical study involved 100 open surgical procedures conducted over 12 months, with half performed using a conventional needle holder and half using the innovative instrument. Precision, ease of handling, fatigue, suturing time, needle slippage, muscle strain, wrist pain, finger strain, and efficiency were compared. Independent-samples *t*-tests and chi-square tests were used to analyze continuous and categorical variables, respectively. The suturing-time distribution differed significantly between the instruments, with a higher proportion of procedures completed within 30 seconds using the innovative needle holder ($p = 0.03$). The innovative instrument also produced significantly lower fatigue scores than the conventional instrument (3.8 ± 1.1 vs. 6.5 ± 1.2; $p = 0.04$). Significant reductions were also observed in muscle strain, wrist pain, and finger strain. The mean efficiency score was significantly higher with the innovative design (0.22 ± 0.04 vs. 0.15 ± 0.03; $p = 0.04$). Needle slippage was less frequent and precision scores were higher, although these differences were not statistically significant. The innovative needle holder improved ergonomic comfort and procedural efficiency without compromising suturing precision. Larger multicenter studies are needed to evaluate its long-term effectiveness and wider clinical applicability.

KEYWORDS: needle holder; surgical ergonomics; open surgery; palming technique; surgeon fatigue; suturing efficiency

1. INTRODUCTION

Suturing is an essential component of many open surgical procedures and plays an important role in tissue approximation, haemostasis, wound closure, and restoration of anatomical integrity. The quality of suturing depends not only on the surgeon's technical skill but also on the stability, precision, and handling characteristics of the instruments used. Among these instruments, the needle holder is particularly important because it enables secure needle grasping, controlled manipulation, and accurate suture placement while minimizing unnecessary tissue trauma. Although widely used across surgical specialties, the conventional ring-handled needle holder has undergone relatively limited ergonomic redesign [1]. Traditional needle holders are generally operated by inserting the thumb and ring finger into circular handles. Common examples include the Mayo-Hegar and Crile-Wood designs. Repeated opening, closing, and locking of the instrument requires a precision grip and sustained activation of the intrinsic muscles of the hand. Use of this type can lead to localized fatigue, finger strain, loss of grip stability and poor fine motor control during prolonged or technically demanding procedures. Fatigue from the instrument may then impact on the efficiency of the operation and can make it harder to keep the needle in place and maintain a quality stitch [2]. Increasingly, musculoskeletal symptoms are understood to be an important occupational issue in surgeons. Pain and discomfort in the thumb, wrist, shoulder, neck and upper limb have been associated with repetitive hand movements, awkward wrist positions, static loading of muscles and prolonged operative postures. A systematic review and meta-analysis identified a substantial burden of work-related symptoms and physical strain among surgeons [3]. There is also wider evidence that there are improvements in ergonomic conditions and assisted surgical technologies that could decrease the incidence of work-related musculoskeletal disorders across different body regions [4]. Ergonomic improvement in surgery should therefore extend beyond posture correction and operating-room arrangement to include the design of frequently used instruments. Ergonomic awareness has demonstrated risk reduction of musculoskeletal symptoms among general surgery residents, showing that simple modification of working technique and instrument use can be beneficial [5]. The recommendations are similar across all three surgical approaches: open, laparoscopy and robotics, including neutral wrist positioning, less static loading and improved alignment of the instruments with the natural hand biomechanics [6]. However, recent developments in the design of the needle holder have involved some extra modifications in the shape of the handle, the mechanism of articulation and the pen-like construction, all with the aim of increasing the precision of the operation and minimizing the effort exerted by the operator. Small redesigned needle holders are suggested to enhance the control during delicate procedures, and articulating devices have shown benefits during simulated tasks in regards to handling and task performance [7]. More recently, pen-style electronic needle holders have demonstrated the use of ergonomic and neurophysiological principles in developing surgical instruments to improve comfort, control and precision [8]. Most modern studies in the field of ergonomics, however, have been applied to the laparoscopic or technology-assisted surgical procedures, and comparatively little research has been conducted on redesigning the basic instruments employed in open surgical practice. The innovative needle holder was therefore developed with elongated rectangular handles and a centrally positioned locking mechanism to facilitate palming. This set-up aims to spread the force over a larger surface area of the hand, minimise the need for repetitive finger movements and promote a more neutral wrist position. The instrument can help reduce fatigue by transferring the mechanical force from small intrinsic muscles to larger muscle groups associated with power grip, and maintain needle control and suturing accuracy. Its performance was evaluated against a standard needle holder in terms of efficiency, precision, handling and surgeon-reported discomfort.

The main innovation assessed in this study was a physically modified ergonomic needle holder for open surgical suturing. The product maintained the traditional working end for maintaining precision in needle grasping whilst the surgeon-instrument interface was enhanced by elongated rectangular handles and a central locking mechanism. The modified handles allowed greater palm contact and a power-grip handle configuration, unlike traditional circular finger rings. The product was designed to reduce the mechanical load on the small intrinsic muscles of the fingers to allow for a more neutral wrist position, to reduce localized finger pressure and to allow smoother locking and unlocking of the instrument during the palming movement. The structural configuration and intra-operative use of it is described in the product development section.

OBJECTIVES

1. To design and develop a modified ergonomic needle holder that facilitates the palming technique during open surgical suturing.
2. To evaluate the ergonomic performance of the modified needle holder and compare it with a conventional ring-handled needle holder.
3. To compare suturing time, precision, needle slippage, and overall procedural efficiency between the two instruments.
4. To assess fatigue, ease of handling, muscle strain, wrist pain, and finger strain associated with the use of each needle holder.

2. MATERIALS AND METHODS

2.1 Study design and setting

A prospective, comparative, analytical study was conducted in the Department of General Surgery, Saveetha Medical College and Hospital. The study included procedures performed in the operation theatres and surgical skills laboratory and was carried out over a period of 12 months. The purpose was to compare the ergonomic and functional performance of an innovative needle holder with that of a conventional needle holder during open surgical suturing.

2.2 Product development and design of the modified ergonomic needle holder

A conventional needle holder was ergonomically modified to achieve the goal of enhancing the surgeon's comfort, grip control and functional efficiency during open surgical suturing. The structure of a conventional ring-handled needle holder was modified without altering its original working end or its integrity. Precision cutting, component forming, alignment and welding procedures were used in a metal workshop to fabricate the instrument.

2.2.1 Working end and jaw configuration

The distal working end was straight and had serrated jaws similar to those of a traditional Mayo-Hegar-type needle holder. Original jaws, box-lock region and shank were kept in order to maintain the traditional needle-grasping mechanism and to prevent modifications which could negatively impact suturing accuracy. The ergonomic modification was able to stay focused at the lock and handle areas by keeping the original working end.

2.2.2 Handle modification

Traditional circular finger rings were removed and replaced with elongated rectangular handles. These handles were designed to permit palm-based handling without having to keep putting the thumb and ring finger into the fixed circular rings. The wider handle contact surface was designed to spread out the force, minimize finger pressure, provide a greater stability of grip, and allow increased involvement of the thenar and hypothenar regions when manipulating the instrument.

2.2.3 Central locking mechanism

The conventional ratchet, which was located next to the circular finger rings, was replaced with a locking mechanism that was located between the rectangular handles. The central location was designed to allow for controlled engagement and disengagement of the instrument to keep the palm grip. It also minimized the need for repeated repositioning of the fingers and prevented interruption of the palming motion during grasping, driving, releasing and re-grasping of the needle.

2.2.4 Material and fabrication

The instrument is made of surgical-grade stainless steel, which ensures its strength, resistance to corrosion, and compatibility with standard sterilization procedures. The fabrication process included dismounting the existing finger rings, creating the rectangular shape of the handles, welding the pieces of the handle and fitting the central locking mechanism. Jaw articulation, shank alignment, handles and locking system were aligned during the manufacture to retain mechanical stability and functional movement.

2.2.5 Ergonomic rationale

The product was designed to support a more neutral wrist position, help the user use a power grip instead of a sustained precision pinch grip, and to reduce repetitive finger movements. The goals were to reduce hand and finger fatigue, increase comfort when using the needle for long periods of suturing, provide palm support for improved proximal control of the instrument, minimize repetitive locking and unlocking of the fingers, and maintain the original jaw design to ensure needle-handling precision.

2.2.6 Anticipated limitations

The modified configuration required an initial learning period as it was a different way to handle the hand-held device than the traditional finger-ring setup. The durability of the welded handle components after repeated sterilization cycles was not evaluated. Its performance in vascular, microsurgical, and other fine-suturing applications requires separate evaluation. The modified needle holder's configuration is presented as below in Figure 1. The full product can be seen in Figure 2, which features elongated rectangular handles and a locking mechanism in the centre. The modified instrument was used intraoperatively and handled using the palm-based technique, as shown in Figure 3A and Figure 3B.

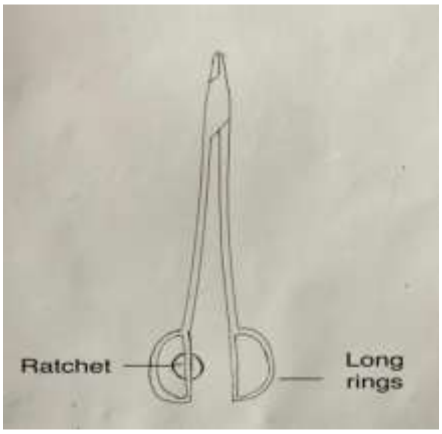

Figure 1. Structural design of the modified ergonomic needle holder

Figure 2. Complete view of the modified ergonomic needle holder with elongated rectangular handles and a central locking mechanism

(A)

(B)

Figure 3. Intraoperative use of the modified ergonomic needle holder during open surgical suturing: (A) palm-supported handling of the instrument and (B) needle manipulation during tissue closure.

2.3 Study population and sample size

A total of 100 open surgical procedures requiring suturing were evaluated. The procedures were divided equally into two groups:

- **Conventional needle-holder group:** 50 procedures in which suturing was performed using a conventional needle holder.
- **Innovative needle-holder group:** 50 procedures in which suturing was performed using the modified ergonomic needle holder.

The sample size was determined on the basis of feasibility and previous studies evaluating surgical ergonomics and procedural performance. Eligible procedures were selected through consecutive sampling and allocated to the two groups in a 1:1 ratio.

2.4 Eligibility criteria

Open surgical procedures requiring suturing of the skin, fascia, or deeper tissue layers were eligible for inclusion. When informed consent was given the general surgery residents and surgeons who conducted these procedures were included. Surgeons with extensive experience in using the new needle holder and those who did not want to participate were excluded as were procedures that did not require suturing. Other exclusion criteria included emergency procedures related to time constraints.

2.5 Study procedure

In the conventional group, suturing was performed using a standard ring-handled needle holder operated through the conventional thumb-and-ring-finger technique. In the innovative group, suturing was performed using the modified ergonomic needle holder with elongated rectangular handles and a centrally positioned locking mechanism. Before clinical use, participating operators were oriented to the palm-based handling method and the engagement and release of the central lock.

During use of the modified instrument, the rectangular handles were supported within the palm to increase the contact area between the instrument and the hand. The instrument was opened, positioned, locked, manipulated, and released while maintaining palm support as far as permitted by the operative task. The retained serrated jaws were used to grasp and drive the surgical needle in the same manner as the conventional instrument.

The procedures were observed and documented on a structured proforma both during and after the procedures. The variables measured were type of surgery, operator experience, suturing time, needle slippage, precision, ease of handling, fatigue, muscle strain, wrist pain, finger strain, overall performance. The physical arrangement and clinical use of the modified product was documented by intraoperative photographs.

2.6 Outcome measures
Procedural and ergonomic parameters were used to compare the two instruments. Procedural outcomes measured were suturing time per stitch, needle slippage, precision of suturing, and efficiency score. Ergonomic outcomes were fatigue (using a VAS); ease of handling; muscle strain; wrist pain; and finger strain. Precision and performance scores were documented using the study proforma, and the overall efficiency score was calculated by dividing the performance score by the suturing time.

2.7 Ethical considerations
The study was approved by the Institutional Ethics Committee of Saveetha Medical College and Hospital under reference number 014/01/2025/IEC/SMCH, dated 29 January 2025. Written informed consent was obtained from the participants, confidentiality was maintained, and patient safety was not compromised. The study was registered with the Clinical Trials Registry–India under registration number CTRI/2026/01/001525.

2.8 Statistical analysis
Data collected were entered into Microsoft Excel and analyzed using SPSS. The mean and standard deviation were used to summarize continuous variables and frequencies and percentages were used for categorical variables. Independent-samples t-test was used for continuous data and the chi-square test was used for categorical data. A p-value of less than 0.05 was considered statistically significant.

3. RESULTS
The performance of 100 open surgical procedures was assessed; 50 procedures were conducted with the traditional needle holder and 50 with the new ergonomic needle holder. The operators included 42 postgraduates and eight senior residents. Both groups were similar with respect to case difficulty and surgeon experience.

3.1 Product functionality during operative use
The fabricated needle holder retained its intended jaw function and was used during the evaluated open surgical suturing procedures. The elongated rectangular handles provided a broader palm-contact surface, while the central locking mechanism enabled locking and unlocking without requiring the conventional finger-ring grip. The retained serrated jaws permitted needle grasping and driving through the established suturing mechanism. The clinical handling configuration of the modified instrument is demonstrated in Figure 3.

3.2 Suturing time and needle stability
The distribution of suturing time differed significantly between the two instruments. Suturing was completed in less than 30 seconds in 22 procedures (44%) performed with the innovative needle holder, compared with 10 procedures (20%) using the conventional instrument. Conversely, suturing required more than 60 seconds in only four procedures (8%) in the innovative group, compared with 10 procedures (20%) in the conventional group. As presented in Table 1, the overall difference in suturing-time distribution was statistically significant ($p = 0.03$). This shift towards shorter completion times is also illustrated in Figure 4.
Needle slippage occurred in eight procedures (16%) performed using the innovative needle holder and in 16 procedures (32%) involving the conventional holder. As shown in Table 1, needle slippage was less frequent with the innovative instrument, although the difference did not reach statistical significance ($p = 0.07$).

Table 1. Comparison of procedural outcomes between the conventional and innovative needle holders

Outcome	Conventional needle holder (n = 50)	Innovative needle holder (n = 50)	*p*-value
Suturing time per stitch			**0.03**
<30 seconds	10 (20%)	22 (44%)	
30–60 seconds	30 (60%)	24 (48%)	
>60 seconds	10 (20%)	4 (8%)	
Needle slippage			**0.07**
Yes	16 (32%)	8 (16%)	
No	34 (68%)	42 (84%)	

Values are presented as number (percentage). A p-value below 0.05 was considered statistically significant.

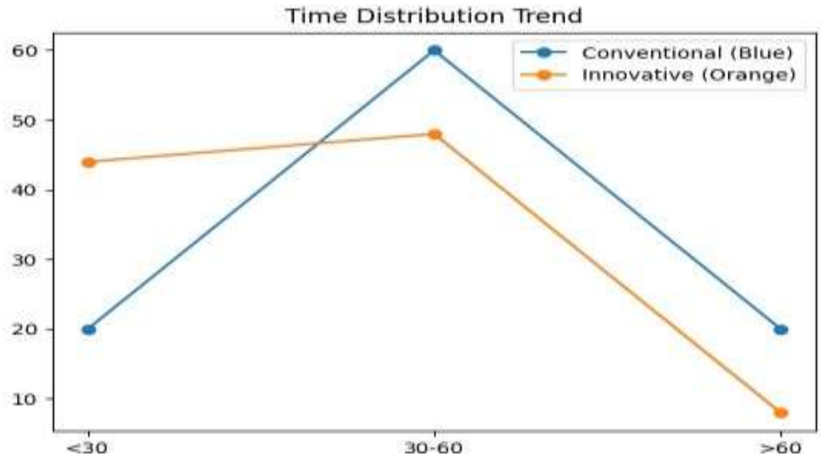

Figure 4. Comparison of Suturing Time per Stitch Between Conventional and Innovative Needle Holders

A greater proportion of procedures performed with the innovative needle holder were completed within 30 seconds, while fewer required more than 60 seconds.

3.3 Fatigue, handling and precision

The innovative needle holder demonstrated a substantial ergonomic advantage in terms of operator fatigue. The mean fatigue score was significantly lower with the innovative instrument than with the conventional holder (3.8 ± 1.1 vs. 6.5 ± 1.2; $p = 0.04$). Ease of handling was higher in the innovative group, with a mean score of 7.4 ± 1.0 compared with 6.2 ± 1.1 in the conventional group; the reported difference was at the threshold of statistical significance ($p = 0.05$).
The mean precision score was also higher with the innovative needle holder (7.6 ± 1.1) than with the conventional instrument (6.4 ± 1.0). As presented in Table 2, the difference in precision scores was not statistically significant ($p = 0.06$). Thus, the reduction in fatigue and improvement in handling were achieved without evidence of reduced precision. The comparative fatigue, ease-of-handling, and precision scores are summarized in Table 2.

Table 2. Comparison of fatigue, handling and precision scores

Parameter	Conventional needle holder (n = 50)	Innovative needle holder (n = 50)	*p*-value
Fatigue score, mean ± SD	6.5 ± 1.2	3.8 ± 1.1	**0.04**
Ease-of-handling score, mean ± SD	6.2 ± 1.1	7.4 ± 1.0	**0.05**
Precision score, mean ± SD	6.4 ± 1.0	7.6 ± 1.1	0.06

SD: standard deviation. Lower fatigue scores indicate less fatigue, whereas higher handling and precision scores indicate better performance.

3.4 Musculoskeletal discomfort

Musculoskeletal discomfort was consistently less frequent with the innovative needle holder. Muscle strain was reported in 18 procedures (36%) in the innovative group, compared with 30 procedures (60%) in the conventional group, representing a statistically significant reduction ($p = 0.04$).
Wrist pain was reported in 14 procedures (28%) using the innovative instrument and 26 procedures (52%) using the conventional instrument ($p = 0.03$). As presented in Table 3, finger strain was lower in the innovative group, occurring in 16 procedures (32%) compared with 28 procedures (56%) in the conventional group ($p = 0.04$). The combined differences in needle slippage, muscle strain, wrist pain and finger strain are displayed in Figure 5.

Table 3. Comparison of musculoskeletal discomfort outcomes

Outcome	Conventional needle holder (n = 50)	Innovative needle holder (n = 50)	*p*-value
Muscle strain	30 (60%)	18 (36%)	**0.04**
Wrist pain	26 (52%)	14 (28%)	**0.03**
Finger strain	28 (56%)	16 (32%)	**0.04**

Values represent the number and percentage of procedures in which the outcome was reported.

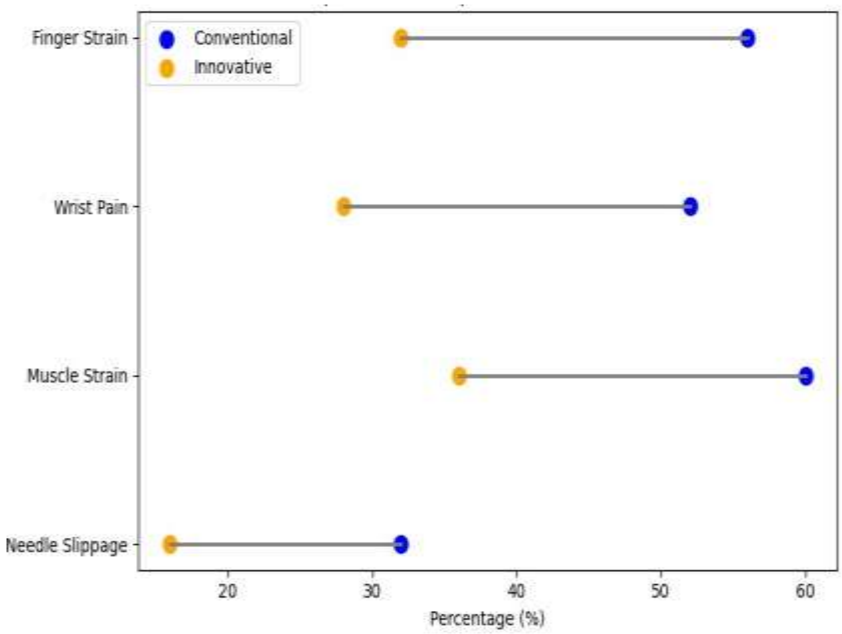

Figure 5. Comparison of Needle Slippage and Musculoskeletal Discomfort Between Conventional and Innovative Needle Holders

The innovative instrument was associated with lower frequencies of needle slippage, muscle strain, wrist pain and finger strain.

3.5 Overall efficiency

The efficiency score was calculated as the performance score divided by the time required for suturing. Mean suturing time was shorter with the innovative needle holder than with the conventional holder (34 ± 5 seconds vs. 42 ± 6 seconds). At the same time, the mean performance score was higher in the innovative group (7.6 ± 1.1 vs. 6.4 ± 1.0).

As shown in Table 4, the mean efficiency score was significantly higher with the innovative needle holder (0.22 ± 0.04) than with the conventional instrument (0.15 ± 0.03; $p = 0.04$). The distribution of efficiency scores is presented in Figure 6.

Table 4. Comparison of performance, suturing time and efficiency score

Parameter	**Conventional needle holder (n = 50)**	**Innovative needle holder (n = 50)**	***p*-value**
Performance score, mean ± SD	6.4 ± 1.0	7.6 ± 1.1	—
Suturing time, seconds, mean ± SD	42 ± 6	34 ± 5	—
Efficiency score, mean ± SD	0.15 ± 0.03	0.22 ± 0.04	**0.04**

Efficiency score = performance score/time required for suturing.

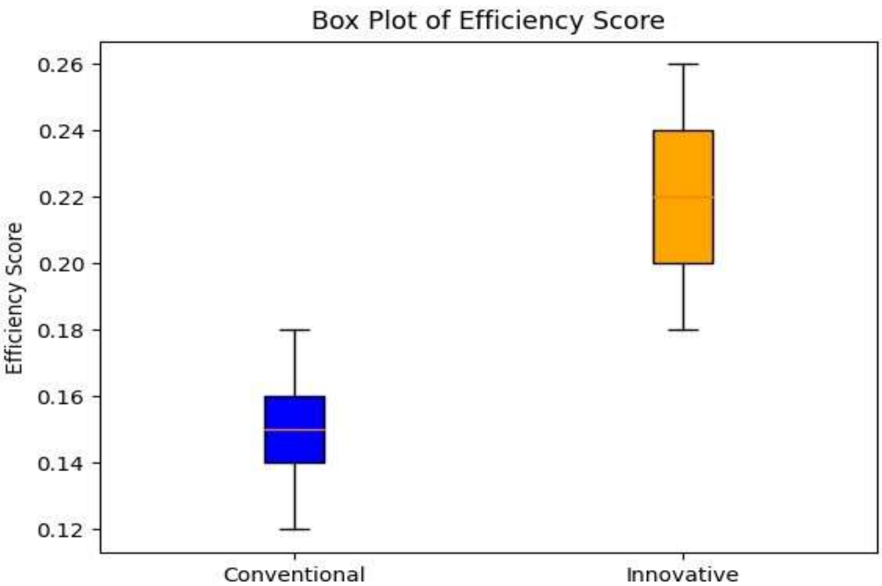

Figure 6. Distribution of Efficiency Scores for Conventional and Innovative Needle Holders

The innovative needle holder had a higher central efficiency score, and its distribution was shifted upward compared with the conventional instrument. Overall, the innovative needle holder was associated with faster suturing, significantly lower fatigue, reduced muscle strain, wrist pain and finger strain, and a higher efficiency score. Needle slippage was less frequent and precision scores were higher with the innovative instrument, although these differences were not statistically significant.

4. DISCUSSION

The present study assessed the innovative needle holder that aimed to enhance the ergonomics of open surgical suturing by replacing the traditional circular finger ring with elongated rectangular handles and incorporating a centrally positioned locking mechanism between the handles. Compared with the conventional needle holder, the modified instrument was associated with shorter suturing time, lower fatigue, reduced muscle strain, wrist pain and finger strain, and a higher efficiency score. Needle slippage was less frequent, while precision and ease-of-handling scores were higher with the innovative design; however, the improvement in precision did not reach statistical significance. Overall, these findings indicate that by altering the surgeon/hand-instrument interface, more efficient procedures could be achieved while also decreasing the immediate discomfort that surgeons experience while suturing. This saving in suturing time could be due to the design of the instrument in terms of using the palm grip and the easy lock system. A palming technique enables the instrument to be manipulated by larger hand and wrist movements instead of repeated insertion and withdrawal of the fingers through the conventional rings. This can decrease movement for repositioning and help provide a more fluid and natural transition between the grasping, driving and releasing of the needle. Palming has been reported as a technique to enhance the rotational control, economy of movement and needle-driver handling especially when the trainees get used to the grip pattern [9]. The increased percentage of stitches made in 30 seconds or less and decreased percentage in 60 seconds or longer in the innovative group thus seem to conform to the intended mechanical benefits of the modified design. The one point that was significant in this investigation was that the intervention that was evaluated was not a change in the suturing technique, but rather a change of the surgical instrument used. The working end of the conventional instrument was purposefully left and the surgeon–instrument contact region was reconfigured. It was possible to measure the comfort, fatigue and handling changes, while separating the functions in order not to significantly alter the established needle grasping mechanism. Elongated rectangular handles provided greater area for hand-to-handle contact while the central locking system provided instrument control without needing to rely on finger rings constantly. The intraoperative photographs demonstrate the use of the product in open surgery suturing, maintaining the critical stages of grasping, driving, releasing and re-grasping.

The innovative needle holder also produced a significantly lower mean fatigue score. A clinical significance of this finding is that the ring-handled tools involve repetitive activation of the thumb, ring finger and intrinsic hand muscles during prolonged use. The rectangular handles, on the other hand, allow the user to make contact with the palm in a larger area and can evenly distribute the pressure. Studies on the ergonomic handles for surgical instruments have demonstrated that the handle shape and size can affect muscle force, wrist position, and contact pressure and comfort. Objective ergonomic evaluations have also shown that the mode of surgery and surgical instrument used may affect muscle effort and fatigue [10]. Appropriately sized handles can reduce concentrated hand loading and improve task performance, supporting the lower fatigue and improved handling observed with the modified instrument [11]. The reductions in muscle strain, wrist pain and finger strain further support the ergonomic rationale of the modified instrument. The traditional finger-ring grip can limit hand placement and possibly involve repeated flexing and extending during the locking and unlocking. The central locking system and palm-oriented handles, however, could allow a more neutral wrist position and thus help minimize pressure on any specific finger. A T-handle design has also been suggested to enhance force transmission and minimize force strain with a more natural hand position and a wider contact area [12]. The findings of the present study indicated that even small changes in handle geometry could help reduce short-term MSD strain but it was not measured in the present study.

The ease-of-handling score was also higher with the innovative needle holder, which is in line with the principles of customized ergonomic design. With awareness of variations in hand size, grip preference and experience of the surgeon, the size of surgical instruments can be standardized. Anthropometric techniques focus on the functional anatomy of the hand, and they highlight the importance of the dimensions, shapes, and contact points of the instruments. A better fit between hand and precision-tool due to the customisation of the grip shape and hand/precision-tool compatibility has been demonstrated to be ergonomically advantageous in modelling precision-handles [13]. The rectangular design of the present instrument may have resulted in greater palm contact and better palm stability when handling the instrument but the individual sizing was not assessed.

From a product-development perspective, the modification retained the familiar mechanical architecture of a conventional needle holder while introducing ergonomic changes at the handle and locking interface. The structural strength and resistance to corrosion of surgical grade stainless steel ensured compatibility with routine sterilization procedures. A rectangular shape was designed for the handles, providing more palm contact, but the centrally located lock decreased the need for repetitive finger locking and unlocking. The practical value of the modification lies in improving the surgeon–instrument interface without replacing the established working mechanism. The dimensions of the handles for various hand sizes, locking force, surface finish, mechanical durability and fine or delicate suturing should be examined during further refinement.

Precision scores were higher with the innovative needle holder, although the difference was not statistically significant. This indicated that the ergonomic modification did not produce a statistically significant improvement in suturing precision but was associated with greater comfort and efficiency. Similar findings have been reported with the evaluation of redesigned laparoscopic handles; there was no consistent correlation between the increased comfort, stability, and subjective usability and significant differences in both task completion and technical accuracy. In this particular aspect, it could be interpreted that perceived comfort and muscle loading were an early indicator of ergonomic benefits, compared to the precision outcome, particularly when the working jaw and grasping mechanism of the instrument remain the same [14]. The original serrated jaws could have been responsible for some of the same accuracy seen across the groups, with the modified handles having the greatest impact on operator comfort and speed.

Although the needle slippage was reduced in the innovative needle holder, this difference was not statistically significant. A change in the gripping surface itself is not likely to have led to an improvement in the stability of the needle. Rather, it could have been due to increased proximal control, increased palm support or decreased fatigue during manipulation. This result, however, was not statistically significant and it is thus viewed as a favourable trend and not as evidence of better needle retention.

This improved performance and reduced suturing time was combined to create the higher efficiency score. An instrument is not ergonomically successful if it becomes more comfortable but loses its technical uses. Based on the obtained results, it can be concluded that the designed modification gave better efficiency without losing the precision. Optimizing the fit between the hand and instrument shape could help increase stability, comfort and satisfaction for users [14]. However, the present results are specific to the procedures and operators tested and cannot be assumed to be representative of all types of fine, vascular or microsurgical suturing.

The images of the fabricated instrument and the intraoperative application visually record the main design changes evaluated in the study. They feature elongated rectangular handles and a central locking system, but with the traditional shank and serrated jaws. This is a visual documentation that complements the quantitative findings by showing the physical configuration and the operative handling of the product.

Several limitations should be considered. This study was performed in one institution with a relatively small number of procedures. Other results, such as fatigue, ease of handling, and discomfort, were subjectively evaluated by the surgeon and could have been subject to surgeon perception. The exact contribution of the surgeon experience, hand size and familiarity of the surgeon with the modified holder to the complexity of the procedure was not fully determined. The long-term durability of the welded parts and the performance after repeated cycles of sterilization were also not evaluated. Furthermore, immediate ergonomic outcome was assessed and not long-term prevention of occupational musculoskeletal disorders. Further multicentre studies with larger sample size, standardized suturing tasks, biomechanical objective measurements and longer follow-up would be valuable.

The repeated sterilization testing of the product, mechanical stress testing of welded parts, locking and unlocking force measurements, and size measurements of the handles of different operators of different hand sizes are also recommended for product-specific validation. The current results are only applicable to the open surgical procedures and operators tested, and further studies are needed in other fine-suturing operations and operators. The amount of familiarity needed before ergonomic advantages of the palm grip can be ensured regularly would also be determined by structured assessment of the learning curve. The study shows that it is possible to achieve measurable ergonomic and functional benefits with a relatively simple modification of a conventional open surgery instrument. The results indicate that surgeon-centred instruments with new handle design, grip configuration and locking system are suitable for further development.

5. CONCLUSION

Designing an ergonomic needle holder to increase operator comfort and procedural efficiency, while maintaining its primary purpose of suturing, was achieved by focusing on a familiar instrument. The instrument maintained the traditional serrated jaws and shank, and utilized elongated rectangular handles and a centrally positioned locking mechanism, instead of the traditional circular finger rings, to allow for palm-based operation, broader distribution of force, fewer repetitive finger movements and a more neutral wrist position. The conventional needle holder was compared to the modified instrument, and lower levels of fatigue, muscle strain, wrist pain and finger strain were reported with the modified instrument. Suturing time was shorter and efficiency score was significantly higher. Handling ease was also improved, but the difference was at the threshold of statistical significance. There were no statistically significant differences in precision scores or needle-slippage rates between the two instruments, suggesting that the instrument with the modified design was not found to have reduced needle control or suturing accuracy. The results suggest that the surgeon-centred ergonomic modifications can be introduced into basic surgical instruments that are widely used in open surgery. However, the results should be interpreted with caution, as this study was limited to one centre, a modest number of procedures, and some ergonomic outcomes were surgeon-reported. The long-term durability, repeated sterilization performance, mechanical strength of the welded components, locking-force requirements, learning effects and suitability for different hand sizes were not fully tested. Further multicentre studies are needed with standardized suturing tasks, objective biomechanical measurements, longer follow-up and testing with vascular, microsurgical, and other fine-suturing procedures. Further evaluation would help refine the handle dimensions, locking mechanism, and design and determine whether the instrument can be standardized for wider clinical use and training.

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