Frimand Needle Holder Reduces Suturing Time and Surgical Stress When Suturing in Palm Grip

Carl-Fredrik Frimand Rönnow, MD, Bengt Jeppsson, MD, PhD, and Henrik Thorlacius, MD, PhD

Abstract

Purpose. The Frimand needle holder (FNH) was developed to facilitate palm grip suturing. In the present study, we wanted to examine the impact of the FNH compared with a conventional Hegar-styled needle holder (HSNH) on suture time and surgical stress. Methods. Thirty-two surgeons were enrolled and they performed sets of 3 continuous sutures on a polyurethane pad with premarked insert and exit points and the time for suturing was measured. Surgical stress was quantified by having the surgeons to perform 10 release maneuvers with the FNH and the HSNH on a needle attached to a scale. The scale sent 5 values per second to a computer. The first measurement of each series was regarded as the starting weight and all subsequent measurements were either regarded as neutral, pressure or traction. The sum of these measurements represented total surgical stress. Results. We found that all surgeons reduced their median suturing time by 16% when using FNH for palm grip suturing with no difference between junior and senior surgeons. Moreover, it was observed that FNH decreased median surgical stress by 62% for all surgeons performing palm grip suturing compared with a conventional HSNH. Conclusion. We conclude that the FNH reduces suture time and surgical stress compared with HSNH when performing palm grip suturing. These findings warrant studies in surgical patients in order to evaluate the potential clinical impact of FNH.

Keywords
operative technique, surgery, trauma, wound healing

Introduction

The gold standard in clinical practice is to minimize time of surgery and tissue manipulation in order to reduce the surgical trauma, which is associated with postoperative complications, such as ileus, surgical site infections and disturbed wound healing. Surgical research has mainly been focused on understanding the mechanisms of trauma reactions and rarely on the impact of different surgical techniques, such as type of suturing and instruments. The majority of currently used needle holders are based on the Hegar needle holder. Needle holders can be gripped in several ways, for example, with the finger or the palm grip. We have recently reported that a majority of surgeons use to some extent the palm grip for suturing. The major reasons for choosing the palm grip are the versatility and the possibility to apply controlled force when palming the instrument. With the traditional Hegar-styled needle holders (HSNH), surgeons start by gripping and locking the needle preferably using the finger grip and then switching to the palm grip to perform the suture. The needle which is inserted in the designated tissue can either be released by returning to the finger grip or by opening the ratchet mechanism by applying a light pressure with the thenar eminence and abduce the opposed shanks. Regardless of release method, there is a potential loss of precision and a risk for uncontrolled movement of the needle, which is at this moment imbedded in the tissue. The impact of these uncontrolled movements on suture time and surgical trauma has not been investigated.

To facilitate palm grip suturing, we have recently developed a new needle holder referred to as Frimand needle holder (FNH). This needle holder is designed to improve palm grip handling while still enabling finger grip suturing with the same standards as the conventional needle holders. One important feature of the FNH is that a spring is inserted in one of the shanks close to the box lock producing a slight outward pressure. The rotatable ratchet mechanism allows the needle holder to open after...
passing the last ratchet. Together, these features of the FNH allow the surgeon to unlock the needle holder, when using the palm grip by simply compressing the opposed shanks.\textsuperscript{3} We have recently shown that a majority of surgeons prefer to suture with the FNH compared with a conventional HSNH when using the palm grip.\textsuperscript{3} However, it is not known whether FNH has merits in terms of shorter suturing times and less surgical stress compared with conventional HSNH.

Based on the considerations above, the aim of this study was to compare suturing time and surgical trauma using FNH and a conventional HSNH when performing palm grip suturing.

**Materials and Methods**

**Study Design and Needle Holders**

This study was carried out between July 2013 and February 2014 at the Department of Surgery, Skåne University Hospital, Malmö, Sweden. Forty-five surgeons employed here were invited to participate in the study. A total of 32 were enrolled (21 men and 11 women), consisting of 20 senior surgeons (defined as more than 2 years of experience as specialist in surgery) and 12 junior surgeons (defined as residents or specialists in surgery with less than 2 years of experience). Two pilot tests were executed prior to the actual trial. The tests were executed with a 16 cm FNH (Stille AB, Solna, Sweden) (Figure 1) and a 16 cm Crile Wood needle holder (CWNH, Stille AB, Solna, Sweden), which is a typical HSNH (Figure 2). The CWNH was chosen as a reference since it matches the FNH in terms of size, jaws, and shanks. The features differing the FNH from the CWNH are (1) improved instrument stability when handling the instrument in palm grip provided by the slightly bent shanks connecting to the outer part of the rings; (2) a slight outward pressure produced by the spring that is inserted in one of the shanks close to the box lock; (3) a rotatable locking mechanism, which allows the needle holder to open after passing the last ratchet (Figure 1). Together, these features allow the surgeon to unlock the needle holder when using the palm grip (Figure 3) by simply compressing the opposed shanks. This is feasible on account of the rotatable locking mechanism, which disengages by passage of the last ratchet and the spring, which opposes the shanks and hence opens the needle holder. The FNH can also be disengaged in palm grip with the thenar eminence in the same manner as the CWNH. The difference when choosing this alternative with the FNH is that the surgeon only has to disengage the ratchet mechanism by applying pressure with the thenar eminence as opposed to applying pressure and abduce as needed with the CWNH. There is no significant difference between the FNH and the CWNH when suturing in finger grip (Figure 4).

Prior to the trial, participating surgeons sutured on porcine skin and small bowels for approximately 30 minutes to get accustomed to the FNH for both the palm and finger grip.\textsuperscript{3}

**Suturing Time**

To assess suturing time, surgeons performed sutures on a polyurethane pad (wound closure pad light, AB Waldemar Larsson, Sollentuna, Sweden) using a 4.0 monofilament suture (Surgipro II, Syneture, 0.6 mm in diameter, 12 mm in curvature diameter) 30 cm in length. The time consumption for the surgeons to perform 3 continuous sutures were measured with a stopwatch. The polyurethane pad was marked with insert and exit points, each
mark had a diameter of 3 mm, allowing for lesser inaccuracies. The insert and exit marks were placed at an 8.5 mm distance since the theoretic suture stride of the half-circle cutting needle with a diameter of 12 mm employed, produces an 8.5 mm suture span on a rotation of 90° (the theoretic suture stride was equal to the base of an isosceles right-angled triangle whose equilateral side was equal to the radius of the needle curvature \(\left(\frac{\sqrt{2}}{2} \times 12\right)/2 \approx 8.49 \text{ mm}\)). The polyurethane pad was marked with 10 cells, each containing 3 sets of the aforementioned insert and exit marks (Figure 5). Surgeons were instructed to perform 3 continuous palm grip sutures on the polyurethane pad, following the premarked insert and exit points. The starting position was defined as the surgeon holding the needle holder, locked in the second ratchet, in the dominant hand and the needle in the nondominant hand.

Surgeons were instructed to initiate the test when the stopwatch was started as indicated by a sharp sound. Measurements were terminated when the 3 sutures were completed and the thread was stretched between the second and third suture. This procedure was repeated 5 times employing both the FNH and the CWNH, switching needle holder every other set of 3 sutures. If the surgeon at any point during the test dropped the needle, the test was declared invalid, and a retest was conducted. If the surgeon placed the suture outside the insert or exit mark they were allowed to adjust suture placement.

**Surgical Stress**

Surgical stress was defined as forces of any given direction executed on the needle. Forces with a downward direction were defined as pressure and forces with an upward direction was defined as traction. The aim of the test was to simulate the release of a needle when using the palm grip. To assess surgical stress, surgeons performed release maneuvers using the palm grip, releasing the needle from the jaws of the needle holder. The needle in question (Surgipro II, Syneture, 0.6 mm in diameter, 12 mm in curvature diameter) was fixed on a corkboard, which was in turn connected to a scale (Model WLC 6/C1/R, Radwag Wagi Elektroniczne, Radom, Poland) (Figure 6). The scale was programmed to transmit five measurements per second to a computer, where measurements were recorded and saved (Pomair Win, Vetek AB, Väddö, Sweden). Surgeons were instructed to lock the needle in the jaws of the needle holder in the second hatch and hold the needle holder using the palm grip (Figure 6).
Measurements started when the surgeons were asked to disengage the needle and terminated when the needle was released. This procedure was repeated 10 times with both the FNH and the CWNH. The first measurement of each series was regarded as the starting value and all subsequent measurements were categorized as either neutral (=starting value), pressure (>starting value) or traction (<starting value). The sum of these measurements was defined as total surgical stress.

Statistical analyses were performed using the SPSS software package (IBM SPSS Statistics for Windows, Version 22.0; IBM Corp, Armonk, NY). To detect possible significant differences between CWNH and FNH, we performed Wilcoxon paired-samples tests on the median values. The effect variables, time for suturing, surgical stress, pressure, and traction were assessed accordingly. Data are given as median and range.

Results

Suturing Time

All surgeons performed 3 continuous sutures on a pre-marked polyurethane pad using the palm grip. This procedure was repeated 5 times with both the FNH and the CWNH. The median time for all participating surgeons to complete 3 sutures was 23.1 seconds when the FNH was used and 27.5 seconds when using the CWNH (Table 1). Thus, adopting the FNH reduced suturing time by 16% for all surgeons (Table 2). We next examined their individual suturing time for all surgeons and found that all surgeons reduced their individual suturing time by a median value of 17% when using the FNH compared with the CWNH (Table 2). We next analyzed junior and senior surgeons separately. It was found that junior surgeons median time to complete 3 sutures was 20.3 seconds when employing the FNH and 24.7 seconds when employing the CWNH (Table 1), corresponding to an 18% reduction in time when suturing with the FNH (Table 2). The median suturing time of senior surgeons was 25.1 seconds when employing the FNH and 28.6 seconds when using the CWNH (Table 1). Thus, FNH decreased suturing time for senior surgeons by 12% when suturing with the FNH (Table 2).

Surgical Stress

All surgeons conducted 10 release maneuvers with the FNH and the CWNH using the palm grip. The release maneuvers were performed on a needle attached to a scale sending 5 values per second to a computer. Surgical stress was regarded as all values diverging from the starting weight of each maneuver. The median surgical stress to perform 10 release maneuvers for all surgeons was 120 g when the FNH was employed and 318 g when the CWNH was used (Table 3). Thus, using the FNH reduced surgical stress by 62% compared with the CWNH (Table 4). Examination of the individual surgical stress...

Table 1. Median Suturing Time and Range for Performing 3 Continuous Sutures.

<table>
<thead>
<tr>
<th>Surgeons</th>
<th>Median Time (s)</th>
<th>Range (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All, CWNH</td>
<td>27.1</td>
<td>18-60</td>
</tr>
<tr>
<td>All, FNH</td>
<td>23.1</td>
<td>14-46</td>
</tr>
<tr>
<td>Junior, FNH</td>
<td>20.3</td>
<td>14-32</td>
</tr>
<tr>
<td>Junior, CWNH</td>
<td>24.7</td>
<td>18-42</td>
</tr>
<tr>
<td>Senior, FNH</td>
<td>25.1</td>
<td>16-46</td>
</tr>
<tr>
<td>Senior, CWNH</td>
<td>28.6</td>
<td>19-60</td>
</tr>
</tbody>
</table>

Abbreviations: FNH, Frimand needle holder; CWNH, Crile Wood needle holder.

Table 2. Suturing Time.a

<table>
<thead>
<tr>
<th>Surgeons</th>
<th>Time (s)</th>
<th>Difference Δ (%)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>4.4</td>
<td>16</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Individual</td>
<td>4.9</td>
<td>17</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Junior</td>
<td>4.4</td>
<td>18</td>
<td>.002</td>
</tr>
<tr>
<td>Senior</td>
<td>3.5</td>
<td>12</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Abbreviations: FNH, Frimand needle holder; CWNH, Crile Wood needle holder.

aTime difference for 3 continuous palm grip sutures when using the FNH in comparison with the CWNH, as described in the Materials and Methods section.

Figure 6. Measurement of surgical stress. The surgeons performed 10 release maneuvers on a needle fixated on a corkboard, in turn attached to a scale. The scale was programmed to send 5 measurements per second to a test computer, where the measurements were logged. The first measurement of each series was regarded as the starting value and all subsequent measurements were categorized as either neutral (=starting value), pressure (>starting value) or traction (<starting value). The sum of these measurements was defined as total surgical stress.
for all surgeons revealed that all surgeons decreased their surgical stress by a median value of 61% when using the FNH compared with the CWNH (Table 4). We also calculated the range of surgical stress evoked by each surgeon, that is, the release maneuvers with the highest and lowest surgical stress. The median highest release stress when employing the FNH was 37 g (range 10-124 g) and 95 g (range 30-467 g) when the CWNH was used. The median lowest release stress when employing the FNH was 2 g (range 0-6 g) and 5 g (range 1-33 g) when the CWNH was adopted. Notably, there was no significant difference between senior and junior surgeons regarding median values or individual reduction in surgical stress when employing the FNH (Table 4). Moreover, we analyzed the surgical stress subdivided in pressure and traction. It was found that median traction for all surgeons was 60 g when the FNH was employed and 195 g when the CWNH was employed (Table 5). The median pressure was 50 g when the FNH was adopted and 102 g when the CWNH was adopted (Table 5). Thus, the FNH attenuated surgical traction by 69% and surgical pressure by 51% when compared with the CWNH (Table 6).
eminence when suturing with both types of needle holders. Although this group is too small for statistical comparison, we observed that they did, however, not differ in aspect of time reduction compared with the rest of the surgeons. Presumably this time reduction is secondary to the spring inserted in the FNH. Thus, the spring is thought to facilitate thenar eminence release by abducting the shanks. This facilitating effect on thenar eminence release can presumably be achieved by inserting a spring in a Hegar needle holder as suggested by Sader. This modified Hegar needle holder would, however, not permit palm grip release by compressing the opposed shanks, which is the more popular of the 2 release methods and only possible with the FNH. Although the clinical consequences of decreased suturing time is not known, reducing suturing time is nevertheless most likely favorable both for the patient and the medical staff. Nonetheless, our data suggest that FNH appears to be faster for palm grip suturing compared with conventional HSNH but whether these findings can be extrapolated to the clinical situation remains to be determined in future investigations.

Traumatic surgical technique is considered to be associated with increased risk of postoperative ileus, surgical site infections and disturbed wound healing. Surgical tissue trauma causes local ischemia and a pathological inflammatory response characterized by increased infiltration of leukocytes and increased vascular leakage and tissue edema. The palm and finger grips have previously been compared regarding suture precision with the conclusion that the palm grip is more accurate although equivalent accuracy can be obtained with the finger grip by allowing wavering (adjustment of the needles’ course). However, suture wavering is assumed to be potentially tissue damaging and should thus be avoided. Moreover, with the existing needle holders one major disadvantage of the palm grip is the loss of precision when disengaging the ratchet mechanism and consequent uncontrolled movement of the needle when it is half through and still imbedded in the tissue. Indeed, Singer et al concluded that the greatest disadvantage of the palm grip when using conventional needle holders is the release maneuver since it easily causes tissue stress. This was one of the main reasons for developing the FNH. Thus, we asked in the present study whether FNH might reduce surgical stress when performing palm grip suturing compared with conventional HSNHs. Interestingly, it was found that FNH attenuated surgical stress by 62% for all surgeons performing palm grip suturing compared with the HSNH. Although the effect of surgical stress on tissue reactions in humans has not been studied in detail, it is interesting to note that Rodrigues et al investigated the amount of tractive forces on a suture that will cause visually detectable tissue damage in different porcine tissues. They reported that the first visual sign of tissue damage appear after 158 g of traction when suturing large bowels. Here, we found that the median traction force when using the CWNH was 195 g when performing 10 release maneuvers, which gives a mean of 19.5 g per suture, which lies far from the threshold for visual tissue damage found by Rodrigues et al. Corresponding median traction values for FNH was 6 g per suture. However, we observed large variations in traction forces and examined each surgeon’s highest traction value. We found that 19% of these were higher than 158 g when the CWNH was employed whereas all sutures executed with the FNH had a value lower than 158 g. These findings suggest that sutures made by FNH might be less prone to cause tissue trauma compared to HSNH when performing palm grip suturing in the colon.

It is noticeable that all participating surgeons experienced reduced suturing time and surgical stress when employing the FNH compared with the CWNH considering the fact that all surgeons had a skewed experience of the 2 instruments. Thus, all surgeons have sutured employing the FNH compared with conventional HSNH for up to as many as 30 years and were presented with the FNH for the first time when conducting the trial. These findings suggest not only that FNH is fast and nontraumatic for grip suturing but also that FNH is easy to learn how to use. We have previously evaluated the same group of surgeons’ perception of the FNH. It was found that 75% of the surgeons would prefer to suture with the FNH and that 97% of the surgeons experienced an advantage when suturing in palm grip. This observation can now be extended to our present findings showing that suturing time and surgical stress are reduced when using the FNH for palm grip suturing. Interestingly, eight surgeons who did not prefer to suture with the FNH due to lack of interest in the palm grip or due to the perception that FNH was disadvantageous in finger grip still reduced their suturing time and surgical stress when using the FNH.

In conclusion, our novel results indicate that FNH is a useful instrument to decrease suturing time and surgical stress when performing palm grip suturing. Next step will be to evaluate FNH in a clinical setting and examine whether these positive findings on FNH can be extrapolated to palm grip suturing in surgical patients.

**Author Contributions**

Study concept and design: Carl-Fredrik Frimand Rönnow, Bengt Jeppsson, Henrik Thorlacius

Acquisition of data: Carl-Fredrik Frimand Rönnow

Analysis and interpretation: Carl-Fredrik Frimand Rönnow, Henrik Thorlacius

Study supervision: Carl-Fredrik Frimand Rönnow, Henrik Thorlacius, Bengt Jeppsson
Declaration of Conflicting Interests
The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: C-FFR is a chair holder in Techmentum AB, which owns the patent rights for the FNH. BJ and HT declare no conflict of interest.

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