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Modification of Surgical Instruments: A Need of the Hour

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ABSTRACT

***Objective*:** To modify some basic surgical instruments for surgeon comfort and better operative results without compromising patient safety.
***Study Design*:** Prospective longitudinal study.
***Place and Duration of Study*:** Combined Military Hospital, Tarbela Pakistan, from Aug 2022 to July 2023.
***Methodology*:** A total of 100 patients needing various surgical procedures were included in the study. Four commonly used instruments, i.e., Needle Extractor, Deaver Liver Retractor, Mayos' Needle Holder and Spermatic Cord Holding Forceps, were picked up for modification. A blacksmith modified them in Tarbela under the direct supervision of the 1st author who conceptualised them. Then, they were practically tested by the 2nd author in Combined Military Hospital Tarbela on 100 patients for Needle Extractors, 20 for Liver Retractor, 12 patients for Angled Needle Holder and 25 for Cord Forceps**.** The 3rd author did the graphic design. Their functioning was graded/categorised into excellent, good, satisfactory and poor, considering surgeon comfort and patient safety.
***Results*:** Excellent functioning (100%) of almost all instruments was achieved with surgeon comfort and patient safety in mind, except for the Liver Retractor, which needs a little further modification/alteration for optimal operative results.
***Conclusion*:** Emphasis is given to the modification of surgical instruments by the young budding surgeons who have ample potential for that and need encouragement in this regard.

Keywords: Innovation, Instruments, Invention, Modification, Surgical.

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INTRODUCTION

Surgery is a manual skill, as the word's origin indicates: Latin Chirurgia; Greek Kheir = hand, and Ourgos = working. Hence, tools and instruments are essential to perform delicate operations because hands and fingers may be inadequate to work at deep anatomical sites. Naturally, instruments are significant for surgical procedures, which are, in fact, extensions of the surgeon's hands. Therefore, the availability of proper instruments is a pressing need of every surgeon. Surgical instruments are either for general use or for a specific procedure. Consequently, they are named for the action they perform (e.g., scalpel, haemostat) or after the name of their inventor (e.g., Kocher's Forceps & Mayo's Needle Holder etc). Minimally invasive procedures, such as laparoscopy and robotics, are recent developments in surgery.[1,2]

Despite the multitude of surgical instruments, the majority of surgeons feel handicapped while performing even routine surgery because of the lack of proper instruments. Moreover, Work-related Musculo-skeletal Disorders (WMSDs) are common among surgeons, and their rates differ with different types of surgeries. These WMSDs are mainly caused by poor surgeon posture or improper instrument designs during operations. They may result in potentially career-altering injuries and practice modification.[3–6] However, almost all the surgeons are so committed to their busy schedules that they do not find time to solve this issue once and for all. This article aims to modify a few surgical instruments to solve some of the problems encountered by the Authors and to ensure surgeon comfort, patient safety, and best operative results.

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METHODOLOGY

The prospective longitudinal study study carried out in Combined Military Hospital (CMH), Tarbela Pakistan, from Aug 2022 to July 2023. The Hospital Ethical Committee approved CMH Tarbela (letter number Coy/1301-Gen/11/2023, dated 7th May 2023).

Inclusion Criteria: patients needing cholecystectomy, inguinal hernioplasty, and laparotomy were included.

Exclusion Criteria: Patients at extremes of age(<20 - >60) and those with severe comorbid/unfit for anaesthesia were excluded.

This is a novel study, and we want to share our experience of modifying some basic surgical instruments at our hospital. During 1st author's surgical experience, spanning over 4 decades, many problems were faced because of the unsuitability of surgical instruments. As mentioned, one is so busy and committed during the prime of life that one ignores these petty things. The same holds for other surgeon colleagues who must have noticed these limitations of surgical instruments but could not spare time to resolve them because of their hectic schedules.

Mainly four of many such inadequacies caught our immediate attention: 1) Difficulty in extracting the needle after passing it through the tissues, 2) Liver injury while retracting it with the help of Deaver Retractor, which is ill-suited for this delicate organ because of its peculiar shape, 3) Difficulty during repairing deep structures. Using a regular Mayo Holder tilts the needle awkwardly in depths, which hinders proper tissue repair; 4) Difficulty in holding the spermatic cord during Inguinal Hernia Repair.

Discontent and unsatisfied with the results, the authors resorted to modifying these instruments to overcome their limitations. This led to devising ways and means to solve particular problems, with the intention of modifying other instruments later on.

Following are some of the surgical instruments conceptualised and modified by the authors: 1) Needle Extractor (Mayo type Holder without Locks): Normally, the needle is extracted with the help of plain or toothed forceps, which is ineffective to catch hold of it firmly; therefore Modified Mayo Holder (GRT's Needle Extractor) is devised which can be used even with the left hand to extract the needle easily, 2) Atraumatic Liver Retractor: Modified Deaver Retractor (GRT's Atraumatic Liver Retractor) can be safely used to retract the liver without risk of injury because of its special shape which fits in the area comfortably. It is a Modified Deaver Retractor, 3) Angled Needle Holder (angled on the side rather than the front). This needle holder (GRT's Needle Holder) can be used while operating on deep structures, e.g., duodenum, ureter, abdominal aorta and inferior vena cava etc. Using regular Mayo Holder tilts the needle awkwardly in depths which hinders proper tissue suturing/repair, 4) Spermatic Cord Holding Forceps Normally Lane's Tissue Forceps (for adults) and Babcock Forceps (for children) are used to holding spermatic cord during inguinal hernia repair. However, they cannot hold it properly because of their improper size. Therefore, Allis Forceps is modified (GRT's Spermatic Cord Forceps) to hold the cord quickly (Figure).

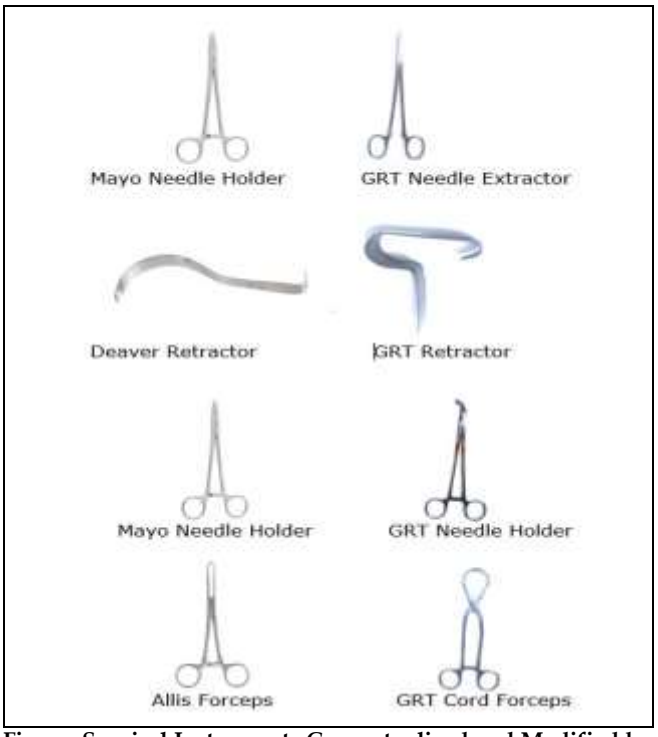

Figure: Surgical Instruments Conceptualized and Modified by the Authors

These instruments were first conceptualised, followed by their graphic design. Then, their prototypes were made with the help of a local blacksmith in Ghazi, Tarbela. Afterwards, Needle Extractor was practically tested on 100 patients (n:100), Deaver Retractor on 20 patients (n: 20), Angled Needle Holder on 12 patients (n: 12) and Cord Forceps on 25 patients (n: 25) with their informed consent.

Surgeon comfort was graded as; excellent, if far more comfortable than original instruments; good, if moderately better than original instruments; Satisfactory, if slightly better than or equal to original instruments; poor, if worse than original instruments. Similarly, patient safety was classified into the following categories; excellent, if no risk to the patient; good if mild risk, e.g., superficial laceration of the organ; satisfactory, if moderate risk, e.g., minor bleeding from the organ. poor: major bleeding / inability to retract the organ properly.[6,7]

Data was collected on structured proforma, and variables were calculated through MS Excel and presented in the form of frequency and percentages.

RESULTS

The results were excellent (100%) in almost all of the modified instruments (Needle Extractor, Needle Holder, and Cord Forceps) except one, the modified Deaver / Liver Retractor, where the results were excellent in 25%/35%, Good in 35%/50%, satisfactory in 40%/10%, and poor in 0/5% regarding surgeon comfort and patient safety, respectively (Table-I and Table-II).

Table-I: Surgeon Comfort and Instrument Function (n=100)

Serial Number	Modified Instruments	Total Number of Patients (n)	Results			
			Excellent n(%age)	Good n(%age)	Satisfactory n(%age)	Poor n(%age)
1	Needle Extractor (Power/Grip)	100	100(100%)	-	-	-
2	Liver Retractor (Proper Retraction & absence of injury)	20	5(25%)	7(35%)	8(40%)	-
3	Needle Holder (Ease of use and absence of needler tilt)	12	12(100%)	-	-	-
4	Cord Forceps (Absence of compression of the cord)	25	25(100%)	-	-	-

Table-II: Patient Safety in terms of no Risk of Complications (n=100)

Serial Number	Modified Instruments	Total Number of Patients (n)	Results			
			Excellent n(%age)	Good n(%age)	Satisfactory n(%age)	Poor n(%age)
1	Needle Extractor	100	100(100)	-	-	-
2	Liver Retractor	20	7(35)	10(50)	2(10)	1(5)
3	Needle Holder	12	12(100)	-	-	-
4	Cord Forceps	25	25(100)	-	-	-

DISCUSSION

Surgical instruments have been used since time immemorial. Trephines for cranial surgeries were discovered in many historical sites, and they were believed to be used by priests to release demons from skulls and relieve headaches. These rough instruments continued to be used in medieval times, but in the renaissance and the post-reformation era, they were a bit refined to cope with the increased audacity of surgeons. amputation sets originated in this period to deal with complex war wounds. Surgical instruments have been manufactured from ivory, bronze, iron, etc. Later, the development of stainless steel and other alloys started the modern evolution of surgical instrumentation. Presently, the replacement of routine metal or steel instruments with novel material is under research to minimise sterilisation, which takes much time compared to the surgical procedure itself.[7]

Recently, rapid development has revolutionised the medical field, for which credit goes to engineers and physicists rather than physicians.[8] Although innovation in surgery has significantly increased over the past 4 decades, yet hardly 3.3% of surgeons have contributed in this regard. Historically, surgical instruments were designed and developed by men. However, presently, almost 30% of surgeons are females in advanced countries, and nearly 90% of them complain about poor instrument design and associated musculoskeletal injuries from use, but very few females hold surgical patents. Female surgeons have a minimal contribution (7-10%) regarding surgical innovation as per USPTO (United States Patent and Trademark Office) and CIPO (Canadian Intellectual Property Office), which is significantly lower than the male inventors stressing the need for playing their role in this regard.[9-11]

The field of surgical innovation is new, which means introducing a new surgical method, a new instrument or a technique or modification of an existing surgical instrument. However, suppose a new surgical procedure or instrument is introduced. In that case, patient safety should always be kept in mind, local rules/regulations should be followed, and ethical practice should be met, i.e., legal requirements should be met.[12,13]

In this study, 4 modified instruments (Needle Extractor – n=100, Atraumatic Liver Retractor – n=20, Angled Needle Holder – n=12 and Cord Forceps – n=25) have been physically tested on the patients. Excellent results were found with all the Instruments except Modified Liver Retractor, where they were excellent only in 25%/25%, good in 35%/50%, satisfactory in 40%/10% and poor in 0%/5%

cases regarding surgeon comfort / patient safety respectively. Reasons for sub-optimal performance are obese patients, low incision, the short handle of the retractor affecting surgeon comfort, and the very straight shape of the retractor blade compromising organ / patient safety. Hence, the final shape of the liver retractor needs to be further modified to increase the length of the handle and change the liver-facing curvature of the Retractor for optimal usage.

Surgical innovation aims include minimal tissue trauma, short operative time, negligible blood loss, surgeon comfort, and patient safety. All these factors ultimately lead to the best operative results. Surgeons must learn new techniques and remember old skills like suturing/knot tying with hands, which may be needed when the new/sophisticated techniques fail.[14]

It is difficult to say when innovation in surgery exactly started. It is curious to introduce novel techniques or new instruments or their modification. Innovation is not without risks; therefore, every possible measure should be adopted to avoid potential risks.[15,16] There is standardisation and government control to ensure safety, non-toxicity, durability, etc.[17,18] Manufacturing is from raw material. Fabrication means modifying existing instruments, which was called the second industrial revolution.[19,20] Users play a vital role in innovation/modification, and many clinicians have contributed significantly. Numerous studies show that users are essential product and service innovation sources in many industries.[21]

The 21st century has already seen advances in laparoscopic surgery, tele-surgery, and robotics, which have changed surgical techniques and the way instruments are developed. Now, the trend is towards minimal access surgery with microsurgical instruments, but there is still scope for macro instruments in open surgery, which is still being practised in underdeveloped countries like Pakistan.

The da Vinci Surgical Robot has revolutionised minimally invasive surgery but lacks the autonomy to work independently. Implementing an AI-based system can allow the Surgeon to listen to, translate, and follow the instructions given by the surgeon in any language. Thus, artificial intelligence tools, such as ChatGPT (Generative Pre-trained Transformer), can be used by robotic surgeons to minimise errors and enhance the safety of surgical procedures and even ask for help if needed.[22]

Autonomous surgical robots will be a reality in the future, and they will be able to "see," "think," and "act" without active human intervention to achieve surgical goals safely and effectively. AI technology may also be used to develop surgical instruments that can adapt to each patient's specific needs. For example, AI-powered surgical instruments may be able to adjust their size and shape to fit each patient's anatomy. They can detect subtle changes in tissue that may not be perceptible by the naked eye. They can also provide the Surgeon with visual and auditory cues, ensuring greater precision, accuracy, efficiency and safety, thus minimising the risk of complications. An example of an AI-enabled surgical instrument is the Smart Tissue Autonomous Robot (STAR), which uses AI to analyse tissue and determine the best path for the surgical instrument to take. The robot can perform suturing and other surgical tasks autonomously, reducing the need for human intervention. Similarly, counting surgical instruments is of utmost importance after completing Surgical Procedures. Applying computer vision technology for instrument counting can improve patient safety and avoid Medical Litigation because of missing or miscounting instruments.[23]

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LIMITATION OF STUDY

Due to limited resources at the Blacksmith in Ghazi, Tarbela, only the angles of the instruments could be modified. However, further alteration of other parameters, e.g., length, width, and thickness of instruments, requires facilities at a proper Surgical Instruments Manufacturing Factory.

CONCLUSION

Creativity is of utmost importance for the future of surgery. Rather than following the beaten track, we need innovators to challenge existing thoughts and develop new ideas to improve the surgical field. This little effort by the Authors to modify surgical instruments, should stimulate and encourage young, budding surgeons to devise ways and means to improve and modify existing instruments and surgical techniques to get the best results. Therefore, we must try our utmost to compete with advanced countries in the field of Surgical Research, and definitely, we have ample potential for that.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

GRT & SUR: Data acquisition, data analysis, drafting the manuscript, critical review, approval of the final version to be published.

UR: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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