Journal of Medical Surgical and Allied Sciences

Review Article

A comprehensive review on haptic feedback for minimally invasive surgery

Jitendra Patel

Associate Professor and Head, Department of Physiology, GMERS Medical College, Vadnagar, Gujarat, India.

***Correspondence**
Jitendra Patel
dr.jrpatel84@gmail.com

Volume: 1, Issue: 1, Pages: 1-12
DOI: https://doi.org/10.37446/jmedsurg/ra/1.1.2023.1-12
Received: 18 July 2023 / Accepted: 30 November 2023 / Published: 31 December 2023

The objective of this article is to provide a thorough examination of the current state of haptic information feedback in minimally invasive surgery (MIS), including research conducted between 1985 and the present. Despite the fact that haptic information input in MIS is currently scarce, the comprehensive analysis emphasises that it represents a potential option. Surgeons might potentially get substantial benefits from receiving more input about force information, which would therefore enhance their surgical accuracy and control. The extant literature highlights a significant knowledge deficit regarding the intricate ramifications of haptic feedback, specifically with regard to the sense of slip and gripping forces. It is crucial to investigate the possible advantages of incorporating supplementary haptic information in order to protect against tissue damage when performing manipulation treatments. It is of the utmost importance to fill this void, since doing so might revolutionise the field of MIS via the mitigation of unintended tissue injury and the improvement of surgical results. By capitalising on technology progress to provide more extensive haptic feedback, surgeons have the ability to enhance their tactile perception, optimise the application of force, and reduce the likelihood of tissue injuries when performing complex surgical procedures.

Keywords: *laparoscopy, tactile perception, force feedback*

Introduction

Minimally invasive surgery (MIS), described by the utilization of long, slight gadgets embedded by means of small entry points, has been by and by for very nearly twenty years and five years. The essential driver behind the quick progressions in MIS is the patient benefits it gives, including diminished injury, truncated hospitalization, and sped up recuperating (Halstead, 1904; Scott, 2009; Cook et al., 2011; Breda et al., 2016; Dawe et al., 2014). In any case, this system presents impressive difficulties for the specialist (Waurick et al., 2007), possibly bringing about an expanded frequency of missteps and outcomes (Yiannakopoulou et al., 2015). The essential elements adding to perceptual troubles incorporate aberrant vision accomplished by an endoscope [camera], as well as circuitous tissue control. These challenges might be additionally classified into hindered dexterity, lessened profundity insight, and reduced haptics. The expression "haptics" is depicted in this setting as the mix of sensation and material discernments [via tangible receptors in the muscles, ligaments, and joints]. At the point when snatched tissue is harmed by the apparatuses, for example, the MIS approach might think twice about tolerant's wellbeing (Coles et al., 2011; Salkini et al., 2010; Aggarwal et al., 2010; Fried, 2008). Discernment issues coming about because of reduced dexterity (Lamata et al., 2018; Kretschmer et al., 2017; Culbertson et al., 2018; Flesher et al., 2016) and profundity insight (Minogue & Jones, 2006; Jeong et al., 2017; Jayne et al., 2017; Kockerling, 2014) certainly stand out enough to be noticed, however the space of decreased haptics has gotten similarly minimal academic examination. Instruments empower the hands to deal with tissue in a roundabout way in MIS. By and by, the exact component by which the gadgets disturb the specialist's tangible experience stays dark. By utilization of gloved hands, the specialist accomplishes semi-direct tissue contact during open surgery, empowering them to touch the tissue's temperature, construction, structure, and consistency. A glove will fairly restrict haptics in contrast with uncovered hands, yet the specialist can in any case promptly see the power utilized during squeezing and the impression of tissue sliding between the fingers. By utilizing this [natural] haptic information, the specialist is fit for changing the applied power to keep a safe hang on the tissue without hurting any. The specialist's capacity to see data through the instruments is basically obscure. In any case, precise representation of the working field is fundamental for the protected control of the tissue. Albeit a few convenient gadgets accessible available need reliable haptic criticism, they keep on being utilized for many MIS exercises. Similarly that most of mechanical careful frameworks work while without haptic information, they keep on executing multifaceted medical procedures (Cao et al., 2007). Despite the capacity to work without haptic information, capability with contemporary hardware in MIS is nowhere near ideal. The da Vinci telemanipulation framework was utilized in an assessment of 148 heart techniques directed utilizing a mechanical careful framework [Intuitive Careful, Mountain View, CA, USA]. Mohr et al. (Rodrigues et al., 2014) trusted that the shortfall of haptics could bring about ID issues. At now, the capability of haptic criticism gadgets in clinical data frameworks (MIS) to improve specialists' capability and relieve patient dangers stays dubious. To improve these frameworks, appreciating the capability of haptic sense in MIS is vital. Without a doubt, the amount of haptic data required shifts among exercises.

Methods

Search Strategy

As per the PRISMA guidelines for the detailing of precise surveys, a methodical audit was done. Free of each other, two journalists [KR, HD] played out the writing search and information extraction; any distinctions in the last information were taken care of by arrangement. A far reaching search was acted in MEDLINE, Embase, and the Cochrane Library by utilizing the accompanying Cross section headings and watchwords: [Surgery] AND [Haptic criticism OR Haptics OR Power feedback] OR [Virtual Reality OR VR OR Recreation OR Simulator]. The review's discoveries were accounted for as per the PRISMA guidelines (Liberati et al., 2009).

Selection Criteria

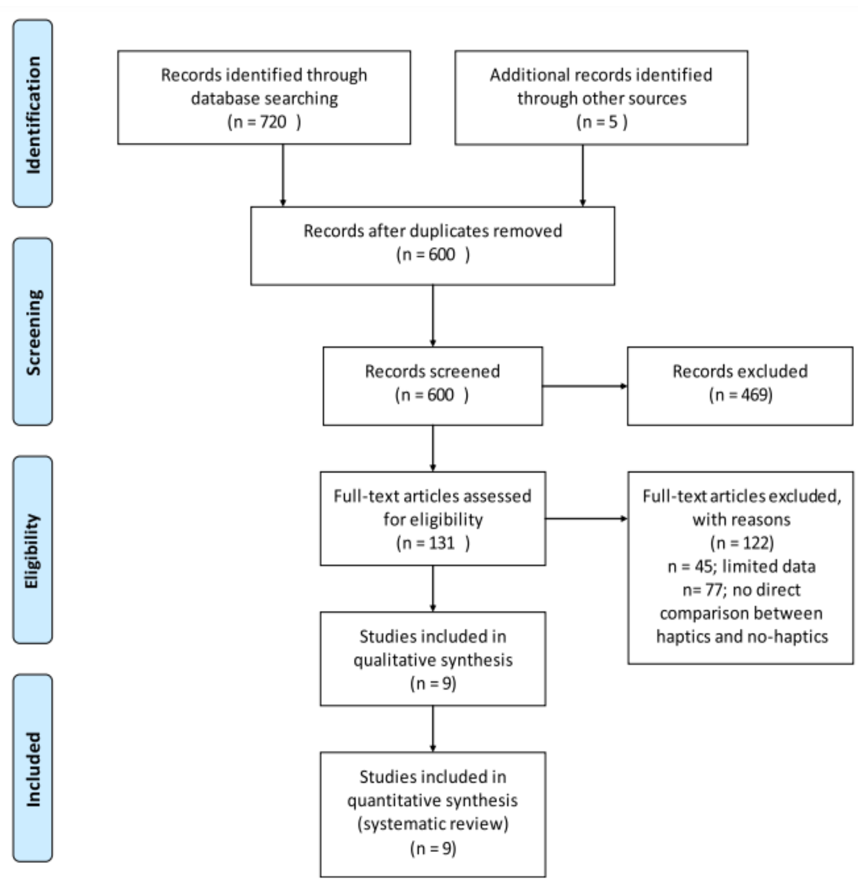

Figure 1. PRISMA flow diagram

All examination papers that introduced information contrasting the impacts of haptic criticism in computer generated experience (VR) reenactment to those without haptic input were incorporated. Prohibited from the investigation were concentrates on that zeroed in on nonhaptic criticism, projected haptic criticism models, or neglected to give an immediate correlation. There were no limitations on the extended time of distribution, and just reports in English text were incorporated. Also, the reference arrangements of the articles that were incorporated were inspected for whatever other exploration that might have been proper for consideration. In the wake of killing copies, a first evaluation of titles and digests was performed to distinguish papers that could be of interest. The writers playing out the writing scan then got these articles for full-text investigation and free information extraction. A manual hunt was led in the reference arrangements of the papers that were gotten to recognize any more relevant references.

The audit's discoveries were ordered into three essential classifications ensuing to information assortment: haptic sensation in augmented experience preparing, haptic reasonableness in minimally invasive mechanical surgery, and haptic sensation in conventional minimally invasive surgery. The classes are further upon in the "Results" segment, with each part beginning with a survey of mechanical improvement helps found and finishing up with an outline of review into what a specialist can genuinely detect through his devices.

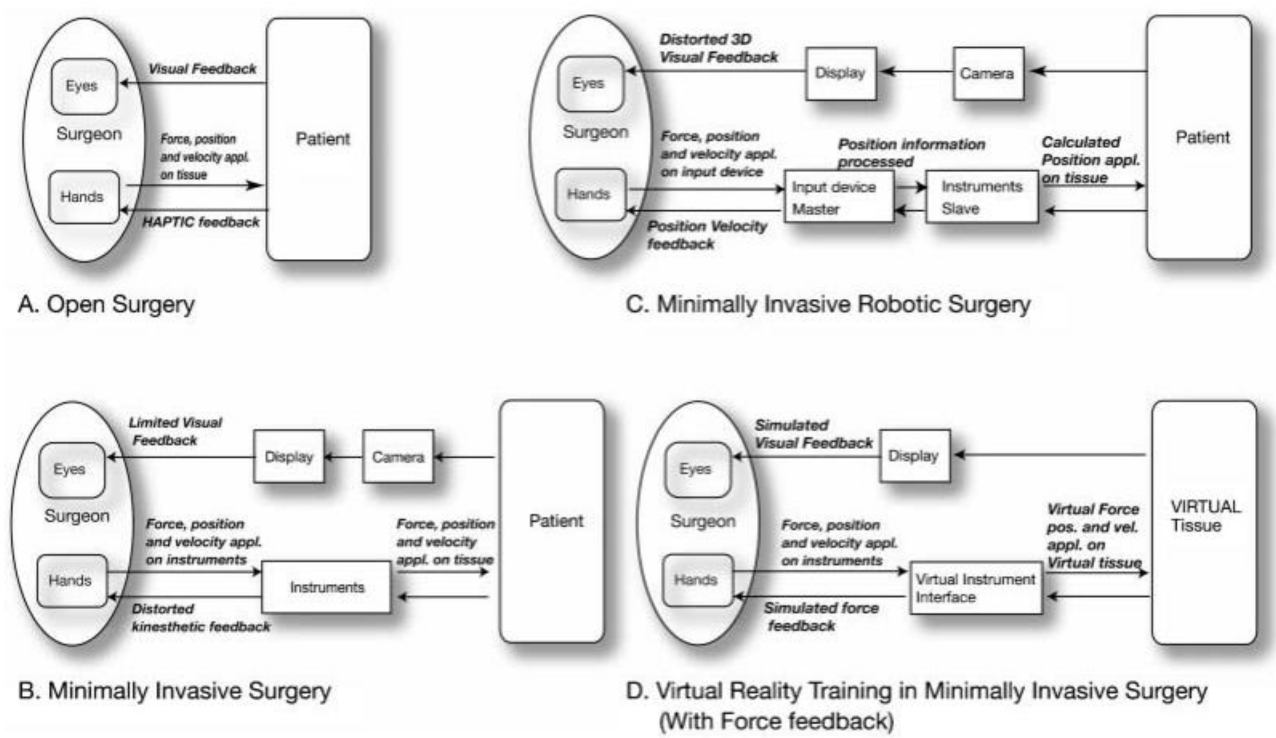

Figure 2. Simplified models include the following: [A] open surgery; [B] minimally invasive surgery; [C] minimally invasive robotic surgery; and [D] force feedback virtual reality training in minimally invasive surgery.

Results

Haptic sensation in conventional minimally invasive surgery [MIS]

On a basic level, to apply command over the tissue, a specialist would need to see the powers, area, and material data delivered by the instruments used to work on the tissue. MIS graspers' ability to see the size, shape, surface, and consistency of tissue has been the subject of exploration (Thompson et al., 2011; Zhou et al., 2012; Hagelsteen et al., 2017; Strom et al., 2006; Panait et al., 2009). Except for surface separation, these examinations exhibit that haptics are essentially reduced in contrast with utilizing the exposed hands; yet, it is feasible to separate the size, shape, and consistency of tissue. Tragically, engineered tissue, for example, sandpaper and plastic 3D squares and cones were utilized in every one of these preliminaries. Hagelsteen et al., 2017, showed that the specialist's exhibition improved when haptic criticism was given during laparoscopy [MIS acted in the stomach alcove] [determine crude shapes, surface, and consistency of springs]. This recommends that specialists obtain the capacity to fathom and decipher the haptic data that was introduced to them. Complex people were the only ones ready to separate unmistakable surfaces [abrasive materials] all the more unequivocally utilizing a dissector rather than their exposed hands. This was possible attributable to their mastery in detecting vibrations and the trocar's switch impact enhancement. In their review, Vapenstad et al., 2013, shown that the responsiveness of reusable dissectors in identifying a reenacted vascular heartbeat was multiple times lower than that of exposed hands. Generally speaking, instrument intervention fundamentally lessens haptic contribution during minimally invasive tasks (Panait et al., 2009; Vapenstad et al., 2013).

Interference components of haptic sensation

The helpful haptic insight is disturbed when items, characteristics, and systems construct the association between the specialist's hands and the treated tissue [refer to Figure 2]. The obstruction factors incorporate the accompanying components (for a complete framework of the impedance factors in customary MIS, allude to Figure 3). The opposition of the trocar to the instrument shaft. As well as forestalling the ejection of insufflated CO2 gas, the trocar brought into the patient's skin, through which the instruments are situated, additionally defends against skin break. Grinding is produced when the shaft of the instrument comes into contact with the sealed shut mass of the trocar during development (van der Meijden & Schijven, 2009). This protection from movement goes against the rubbing. Albeit the rubbing fluctuates across trocars, it stays steady and some trocars may encounter it past 3N (Panait et al., 2009; Chmarra et al., 2008).

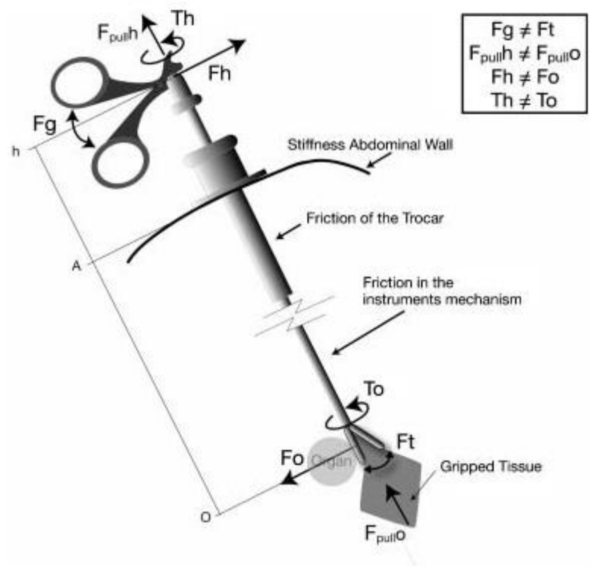

Figure 3. Factors of interference in minimally invasive conventional surgery. As a result of the mechanism of the instrument, the grip force [Fg] and the tip force [Ft] are not equivalent. Due to the resistance of the abdominal wall and the scaling factor [ideal Fh5Fo[OA/Ah]], the hand force [Fh] is not equivalent to the organ force [Fo]. Trocar friction causes the force exerted at the handle [Fpullh] to be less than the force exerted at the organ [Fpullo]. The torque exerted at the handle [Th] is also affected by the friction of the trocar.

The stomach wall opposition experienced while playing out a switch movement. Since biomechanical characteristics are not isotropic and change across people, the opposition of the stomach wall [skin, subcutaneous fat, facial, and muscle layers] could vary when the instruments are turned. The power force, according to the stomach wall, may fluctuate somewhere in the range of 0 and 0.7 Nm in view of the slant degree and bearing (Panait et al., 2009). Reflecting and scaling of tip powers. Because of changing over the instrument shaft into a switch at the cut site, the powers acting at the instrument's tip [perpendicular to the shaft] are scaled and reflected (Minogue & Jones, 2006). The length of the switch not entirely set in stone by the objective site, the thickness of the patient's stomach wall, and the addition profundity of the gadget. In principle, the power experienced by the specialist's hand during instrument tissue contact might differ somewhere in the range of 0.2 and 4.5 times that of the genuine power delivered. This outcomes in an extra haptic criticism twisting. The tensions applied by the specialist on the instrument during its contact with the organs were evaluated inside the scope of 0 to 10-12 N [Ft] (Panait et al., 2009; van der Meijden & Schijven, 2009; Heijnsdijk et al., 2002). A haptic encounter is at its pinnacle when the translational speed is low, the point of slant is negligible, and the mechanical instrument is both productive and exact. The obstruction attributes of haptics may reflect those seen when the organ is in contact. Recognizing somesthesic data created by the organ from data emerging from contact or opposition of the stomach wall is quite difficult for the specialist (Panait et al., 2009).

Haptic sensation in virtual reality training [VRT]

VRT is utilized to train specialists on a wide assortment of tasks. A properly planned VRT framework should give true vibes of surgeries. In this manner, without even a trace of sensation input, a test system neglects to sufficiently set up the student to oversee and dominate the disturbances and obstructions that emerge during MIS. Creating hapticVRT-frameworks is the subject of impressive consideration, regardless of the way that the meaning of haptic criticism is still minimal comprehended (Ottensmeyer et al., 2000; Carter et al., 2005). Figure 4 presents a schematic portrayal of a VRT framework that consolidates haptic input.

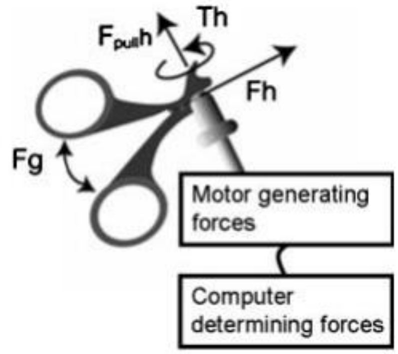

Figure 4. A schematic illustration of a haptic feedback-enabled virtual reality training simulator. A motor produces forces, which are then computed by a computer.

To precisely reenact the way of behaving of tissues and instruments, information on the mechanical attributes of organs is critical. This is trying to do, in any case, because of the way that strong organs (liver, spleen, and pancreas), empty organs (gallbladder, stomach, and colon), and solid and ailing tissue display nonlinear pressure strain conduct and answer distinctively to control (Carter et al., 2001; Brouwer et al., 2001). Certain researchers have endeavored to procure these mechanical characteristics, involving digestive tissue as an illustration (Kitagawa et al., 2005). Albeit certain apparatuses for getting in vivo direct tissue consistence and calculation change have been laid out (Basdogan et al., 2004), much remaining parts muddled. The juncture of mechanical difficulties and this lack in understanding muddles the execution of sensible tissue conduct in VRT frameworks. Various investigations (Cavusoglu & Tendick, 2000; Schijven & Jakimowicz, 2003) gave an exhaustive assessment of the mechanical difficulties and basic components that manifest in haptic delivering. Seen tissue consistency not entirely set in stone by haptic information. Sim et al., 2006, demonstrated the way that experts could remember the surface of tissue exclusively by seeing it, because of the improvement of a material memory. Especially unpracticed people need haptic data in VRT when consistency data was required (Sim et al., 2006). In their academic article, Schijven and Jakimowicz (Wagner & Howe, 2005) led a complete examination of the twelve most huge VRT-frameworks that were by and by open. They derived that among the twelve frameworks analyzed, simply three offered the ability to consolidate force input, while six really included it. By and by, these frameworks were restrictively costly and of inadequate quality.

Performance with augmented haptic information feedback

Is it plausible to upgrade execution in a VRT framework by including haptic data for client commitment? There was little exploration that tended to this request. In their review, Wagner et al. (Ström et al., 2006) shown that force criticism has the ability to force actual constraints on the developments of an administrator, accordingly latently compelling the hand and diminishing mistake preceding the administrator having the option to intentionally respond to the power input. 80% less undesirable intrusions entered a virtual wall in size when force criticism was incorporated rather than not being available. Mistake decrease was accomplished in 150 milliseconds with sensation show criticism in the wake of arriving at the virtual wall, while vibration show input called for greater investment. In their review, Houtsma & Keuning, 2006, explored whether the utilization of power criticism into VRT during the principal phases of preparing improved execution on a diathermy test. They arrived at the resolution that haptic information might be critical during the primary phases of expertise securing preparing. A mouse-based increased force input superior execution on a virtual PC development task (Acosta & Temkin, 2005); the client experienced more protection from mouse development as the mouse moved toward the goal.

The included examination recorded a scope of results, demonstrating that haptics had a changed effect. Five exploration (Cao et al., 2007; Zhou et al., 2012; Panait et al., 2009) shown huge great results; these investigations contrasted haptic-empowered preparing with preparing without haptics and found that haptic input better different boundaries. In their review, Kim et al., 2017, inspected the effect of three unmistakable levels of computer generated reality haptic constancy on execution: a model without force input, a direct model (addressing the most un-precise high-loyalty mode), and a nonlinear model (addressing medium devotion). The push/pull evaluation task utilized in this exploration uncovered that the haptic-prepared bunch showing the best constancy followed through with jobs in the most limited measure of time. Hagelsteen et al., 2017, exhibited that haptic criticism speeds up the mastering of laparoscopic abilities by novice learners and is a significant device for this reason. A similar examination of key laparoscopic capacities, for example, "instrument route," "getting a handle on," "fine analyzation," and "stitching," between a companion that got haptic and nonhaptically prepared people exhibited that the haptic-prepared bunch got done with all tasks undertakings quickly, an increment of 69 minutes (32 percent) over the benchmark group's 215 minutes ($p < 0.002$).

Study	Objective	Methodology	Findings
Halstead WS, 1904	Addressed the training of surgeons	Examined surgeon training methods	Outlined aspects of surgeon training methodologies
Scott IA, 2009	Explored errors in clinical reasoning	Investigated causes of clinical errors and their remedial strategies	Identified causes of clinical errors and potential remedial actions
Cook DA et al., 2011	Explored technology-enhanced simulation in health professions education	Reviewed the impact of simulation in healthcare education	Highlighted benefits and applications of simulation in healthcare training
Breda A et al., 2016	Conducted a systematic review of virtual reality simulators for robot-assisted surgery	Reviewed VR simulators in robot-assisted surgery	Summarized findings on VR simulators' effectiveness in robotic surgery
Dawe SR et al., 2014	Evaluated the transfer of surgical skills after simulation-based training	Explored the transferability of skills from simulation to practice	Identified factors affecting the transfer of skills learned in simulation
Waurick R et al., 2007	Investigated the impact of the European working time directive on education and clinical care	Studied the effects of working time regulations on medical training	Explored implications of working time regulations on medical education
Yiannakopoulou, et al., 2015	Reviewed virtual reality simulators and laparoscopic surgery training	Examined the role of VR simulators in laparoscopic training	Highlighted the benefits of VR simulators in laparoscopic skills training
Coles TR et al., 2011	Surveyed the role of haptics in medical training simulators	Analyzed the use of haptic feedback in medical simulators	Summarized the importance and impact of haptic feedback in medical training
Salkini MW et al., 2010	Explored haptic feedback in laparoscopic training using the LapMentor II	Investigated the role of haptic feedback in laparoscopic skills development	Identified the impact of haptic feedback in laparoscopic training
Aggarwal R et al., 2010	Examined the role of training and simulation in patient safety	Reviewed the impact of training and simulation on patient safety	Explored the correlation between training and patient safety
Fried GM, 2008	Assessed FLS competency using simulated laparoscopic tasks	Examined the assessment of laparoscopic competency using simulated tasks	Summarized the role of simulated tasks in assessing laparoscopic skills
Lamata P et al, 2018	Presented a conceptual framework for laparoscopic VR simulators	Developed a framework for VR simulators in laparoscopic training	Outlined key components and considerations for laparoscopic VR simulators

To recreate the evaluation of errand trouble, Cao et al., 2007, expanded mental weight by the utilization of mental number juggling all through the reproduction. The discoveries of this examination exhibited that the mix of haptic criticism and mental stacking brought about a more articulated improvement so as to-task culmination without haptics contrasted with their presence. Zhou et al., 2012, gave proof that the utilization of haptics not just brought about a more steady expectation to learn and adapt for students contrasted with control gatherings, yet in addition sped up the learning rate (70% versus 64% in NoHaptics bunch). Moreover, they come to the end result that less attempts were adequate until execution arrived at a level. Notwithstanding the way that this exploration exhibits that haptics diminish execution fluctuation and increment consistency in the beginning phases of preparing, the combination of the expectations to learn and adapt of the two gatherings during resulting meetings proposes that haptics give restricted benefits at this level. Strom et al., 2006, closed by differentiating the utilization of right on time and late haptics. Following a one-hour waste of time period, bunches in this hybrid review were presented to either haptic or nonhaptic preparing, trailed by hybrid. The outcomes introduced by the creators show that the gathering that got early haptics preparing (two hours) performed observably better in control and point diathermy assignments contrasted with the gathering that got later haptics openness ($p < 0.05$).

Discussion

This audit underscores the absence of consistency and adequacy of existing examination about the legitimacy of haptics and its utilization in preparing. The possibility of haptic criticism has huge significance in minimally invasive surgery (MIS), and regardless of its perplexing nature, its advancement has not been obstructed by the multiplication of haptic-empowered hardware. As a general rule, the discoveries show that haptic criticism might have a spot in careful reproduction preparing, as six examinations (Cao et al., 2007; Zhou et al., 2012; Vapenstad et al., 2013) exhibited a beneficial outcome of preparing execution on various undertakings, from major laparoscopic abilities to completely recreated tasks, when contrasted with no haptic criticism. With haptics, execution on an assortment of approved assessment measurements is upgraded in every one of the six of these examinations contrasted with the shortfall of haptics. Research that analyzed the expectations to learn and adapt of members (Hagelsteen et al., 2017; Strom et al., 2006) found that haptic criticism further developed learning, as confirmed by a vertical pattern in task capability among students contrasted with the people who didn't get haptic criticism. These increases were particularly prominent during the underlying periods of preparing. While the practicality of expertise move from VR reproductions without haptic contribution to the working room has been displayed in the past (Chmarra et al., 2008), the ideal second for coordinating haptics into careful preparation stays only conflict. In their correlation of laparoscopic beginners finishing essential responsibilities with and without haptic criticism, Panait et al. (Vapenstad et al., 2013) found that fledglings performed better with haptic, subsequently reinforcing the reasoning for early haptic acceptance. Zhou Hagelsteen et al., 2017, who found that confounded errands were learnt all the more successfully in the beginning phases of careful preparation when haptic input was free, and who featured this beginning stage as the crucial opportunity to consolidate and highlight haptic signs, agreed with these outcomes. The need and utilization of haptics may contrast relying upon the multifaceted nature of the given work. As indicated by Chmarra et al., 2008, test systems with haptic criticism are essential for strategies requiring force application, for example, laparoscopic tie tying or inside taking care of. Nonetheless, test systems without haptic input can be utilized to prepare less difficult undertakings, including stake move or errands that intensely depend close by eye coordination, similarly as with the previously mentioned three investigations going against the norm, current test system restrictions in realistic and actual tissue displaying may reduce the utility of computer generated reality (VR) preparing for reproducing complex full methodology, despite everything haptics, at more elevated levels of intricacy. This might change as programming models keep on progressing at a fast rate.

Research has shown that the utilization of minimally invasive methods fundamentally lessens haptics. Be that as it may, responsiveness qualities fluctuate significantly among instruments. Roundabout tissue contact, trocar grinding, stomach wall opposition, scaling and reflecting of tip powers, and erosion in the framework mechanics all hinder apparent haptics. During MIS, these impedance parts of haptic sensation might be essentially as critical as the powers of contact with the organs. As of now, MIS instruments, MIRS frameworks, and VRT-frameworks that give adequate haptic data input are not industrially accessible. In any case, haptic criticism is expected during MIS (Oakley et al., 2000). At the point when a few examination associations proclaim themselves to have made haptic data criticism frameworks, they are, truly, alluding to compel data input. Position criticism is the main ability of monetarily accessible MIRS frameworks on the grounds that to the over the top costs and relentless unsteadiness issues related with coordinating power and material data input into these complex frameworks. During MIRS, specialists are expected to gauge applied contact powers by the visual perception of tissue misshapening and variety change. Especially when a few gadgets are set during a convoluted treatment, some of them might be disguised while getting a handle on tissue. At the point when this happens, force input might be advantageous for hold control. The current VRT-frameworks give either non-practical or non-utilitarian haptics because of restricted comprehension of the mechanical attributes of live tissue, notwithstanding innovative difficulties that upset the improvement of sensible haptics. Specialists would get benefits from additional information about the extents of power applied on tissues. While much review has been directed on the indication of translational powers, examinations concerning the data criticism of slips and hold powers are remarkable. Various expert slave frameworks and serious level of-opportunity haptic gadgets need grippers or don't give force criticism in the gripper DOF. Liked regardless of anything else, MIS instruments need to incorporate total haptic criticism, which involves giving the administrator slippage and surface information, notwithstanding force input across all levels of opportunity of control. Subsequently, the specialists might have the vibe of controlling the tissue straightforwardly. Complete haptic criticism, as recently portrayed, is presently out of reach because of innovation impediments. Carrying out a framework that offers fractional haptic data criticism might be dangerous because of the subsequent sensor-actuator irregularity. By the by, experimental proof recommends that information relating to translational powers and hold force don't block each other, empowering their particular show without prompting misconception. The inclination for lessening impedance factors with precisely more effective gadgets might shift in view of the particular current task. It appears to be that an improved haptic data show is the predominant strategy. In any case, extra criticism signals are just worthwhile because they don't force an extra mental exertion. In a cannulation task, force criticism diminished botches without requesting the client's mental consideration (Ström et al., 2006). Force criticism may unquestionably limit the psychological exertion related with ace slave exercises in spaces other than medication (Lessard et al., 1995; Chou & Wang, 2001). While haptic presentations may not give data in that frame of mind of opportunity (DOFs), they might give aloof techniques, for example, tangible substitution, that are difficult to execute with force data alone. A tangible replacement based haptic data show, then again, is considerably less costly and easier to introduce. A specialist's exhibition might be upgraded by haptic data gave through tactile substitution when appropriately carried out, as opposed to the shortfall of any haptic data input. Force data sent by tangible replacement further develops execution in non-clinical spaces, as shown by vibro-material showcases (Barbagli & Salisbury, 2003) or blended hear-able and vibro-material presentations (Oakley et al., 2000). Since it is extremely challenging, in the event that certainly feasible, to convey "complete" haptic data criticism (force in all DOFs and material data on slips) without adding unjustifiable mental strain, tangible substitution can barely upgrade haptic criticism. The forthcoming direction of haptic reconciliation in careful reproduction envelops its utilization in automated supported surgery as well as different progressions in specialized plan. Possibly, later on, it would be worthwhile to make careful apparatuses that capability as hand augmentations for the specialist and empower the appraisal of contact powers between the instrument and the tissue (Jacobs et al., 2007). At this present, mechanical stages do exclude material information. Nonetheless, there is hypothesis that the utilization of haptic criticism in automated surgery could possibly lessen specialized botches, tissue harm, and functional span (Heijnsdijk et al., 2002). An early examination led by Jacobs et al. displayed the expected advantages and impact of incorporating haptic and visual input into mechanical preparation. In contrast with task exhibitions with simply visual information, the discoveries recommended that haptic criticism expanded preparing exhibitions as far as errand finish time, precision, and number of missteps (Famaey & Vander Sloten, 2008). Despite the commendable benefits it is said to give, haptic innovation is still in its early stages. There are other likely roads for upgrading haptic input. One such road is by means of the execution of more practical tissue models, which would empower the age of additional regular responses and connections with designs and tissues (Niitsu et al., 2013)..

Conclusion

Execution in every aspect of minimally invasive surgery might be improved with the utilization of expanded force data, and specialists gain from the additional information given forcibly data. Because of the instinctive idea of this data, a haptic presentation is suggested; in any case, a multimodal show might give more prominent inclination. In general, MIS has seen a lack of exploration directed in the space of expanded haptics. As to pressures and the view of slippage, specifically, the advantages that extra haptic data might give to limit tissue hurt during control are minimal perceived. Upgrading haptic data contribution to MIS to further develop haptic discernment could have positive ramifications for patient security. The expanded utility of material VR test systems, in spite of their greater expense comparative with sans haptic partners, has been the subject of little examination. Thought should be given to the money saving advantage examination of such a rewarding showcasing device and whether or not haptics is a genuine careful necessity. As a feature of the pattern toward "ultrarealistic" test systems, haptics have been effectively carried out in different fields, including space investigation and flight reenactment preparing; nonetheless, extra examination is important to decide if haptics ought to be generally integrated into careful reproduction.

Author contributions

Jitendra Patel was involved article development and writing of review of article.

Funding

No funding

Conflict of interest

The author declares no conflict of interest. The manuscript has not been submitted for publication in other journal.

Ethics approval

Not applicable

Competing Interests

The author declares no conflict of interest. The manuscript has not been submitted for publication in other journal.

References

Acosta, E., & Temkin, B. (2005). Haptic Laparoscopic Skills Trainer with Practical User Evaluation Metrics. Studies in Health Technology and Informatics, 111, 8–11.

Aggarwal, R., Mytton, O. T., Derbrew, M., et al. (2010). Training and simulation for patient safety. Quality & Safety in Health Care, 19, i34–i43. https://doi.org/10.1136/qshc.2009.038562

Bala´zs, M., Feussner, H., Hirzinger, G., Omote, K., et al. (1998). Replacing Mechanical Joints in Laparoscopic Forceps with Elastic Beams for Improved Pressure Control and Sensitivity: A New Tool for Minor-Access Surgery. IEEE Engineering in Medicine and Biology Magazine, 17, 45–48.

Barbagli, F., & Salisbury, K. (2003). The Effect of Sensor/Actuator Asymmetries in Haptic Interfaces. Proceedings – 11th Symp Haptic Interfaces for Virtual Environment and Teleoperator Systems, 140–147.

Basdogan, C., De, S., Kim, J., Muniyandi, M., Kim, H., et al. (2004). Haptics in Minimally Invasive Surgical Simulation and Training. Proceedings – Haptic Rendering – Beyond Visual Computing, IEEE Computer Society.

Breda, A., Territo, A., Moglia, A., et al. (2016). Platinum priority review-education a systematic review of virtual reality simulators for robot-assisted surgery. European Urology, 69, 1065–1080. https://doi.org/10.1016/j.eururo.2015.09.021

Brouwer, I., Ustin, J., Bentley, L., Sherman, A., et al. (2001). Measuring in Vivo Animal Soft Tissue Properties for Haptic Modeling in Surgical Simulation. Studies in Health Technology and Informatics, 81, 69–74.

Cao, C. G. L., Zhou, M., Jones, D. B., Schwaitzberg, S. D. (2007). Can surgeons think and operate with haptics at the same time? Journal of Gastrointestinal Surgery, 11, 1564–1569. https://doi.org/10.1007/s11605-007-0279-8

Carter, F. J., Frank, T. G., Davies, P. J., McLean, D., et al. (2001). Measurements and Modeling of the Compliance of Human and Porcine Organs. Medical Image Analysis, 5, 231–236.

Carter, T. J., Sermesant, M., Cash, D. M., Barratt, D. C., et al. (2005). Application of Soft Tissue Modeling to Image-Guided Surgery. Medical Engineering and Physics, 27, 893–909.

Cavusoglu, M. C., & Tendick, F. (2000). Multirate Simulation for High Fidelity Haptic Interaction with Deformable Objects in Virtual Environments. Proceedings – IEEE International Conference on Robotics and Automation [ICRA 2000], 2458–2465.

Chmarra, M. K., Dankelman, J., Van Den Dobbelsteen, J. J., & Jansen, F. W. (2008). Force feedback and basic laparoscopic skills. Surgical Endoscopy and Other Interventional Techniques, 22, 2140–2148. https://doi.org/10.1007/s00464-008-9937-5

Chou, W., & Wang, T. (2001). The Design of Multimodal HumanMachine Interface for Teleoperation. Proceedings – IEEE International Conference on Systems, Man and Cybernetics, 3187–3192.

Coles, T. R., Meglan, D., John, N. W. (2011). The role of haptics in medical training simulators: a survey of the state of the art. IEEE Transactions on Haptics, 4, 51–66. https://doi.org/10.1109/TOH.2010.19

Cook, D. A., Hatala, R., Brydges, R., et al. (2011). Technology-enhanced simulation for health professions education. JAMA, 306, 978–988. https://doi.org/10.1001/jama.2011.1234

Culbertson, H., Schorr, S. B., Okamura, A. M. (2018). Haptics: the present and future of artificial touch sensation. Annual Review of Control, Robotics, and Autonomous Systems, 1, 385–409. https://doi.org/10.1146/annurev-control-060117-105043

Dawe, S. R., Windsor, J. A., Broeders, J. A. J. L., Cregan, P. C., Hewett, P. J., Maddern, G. J. (2014). A systematic review of surgical skills transfer after simulation-based training. Annals of Surgery, 259, 236–248. https://doi.org/10.1097/SLA.0000000000000245

Famaey, N., & Vander Sloten, J. (2008). Soft tissue modelling for applications in virtual surgery and surgical robotics. Computer Methods in Biomechanics and Biomedical Engineering, 11, 351–366. https://doi.org/10.1080/10255840802020412

Flesher, S. N., Collinger, J. L., Foldes, S. T., et al. (2016). Intracortical microstimulation of human somatosensory cortex. Science Translational Medicine, 8. https://doi.org/10.1126/scitranslmed.aaf8083. 361ra141.

Fried, G. M. (2008). FLS assessment of competency using simulated laparoscopic tasks. Journal of Gastrointestinal Surgery, 12, 210–212. https://doi.org/10.1007/s11605-007-0355-0

Hagelsteen, K., Langegard, A., Lantz, A., Ekelund, M., Anderberg, M., & Bergenfelz, A. (2017). Faster acquisition of laparoscopic skills in virtual reality with haptic feedback and 3D vision. Minimally Invasive Therapy & Allied Technologies, 26, 269–277. https://doi.org/10.1080/13645706.2017.1305970

Halstead, W. S. (1904). The training of the surgeon. Bulletin of Johns Hopkins Hospital, 15, 267–275.

Heijnsdijk, E. A. M., Dankelman, J., & Gouma, D. J. (2002). Effectiveness of grasping and duration of clamping using laparoscopic graspers. Surgical Endoscopy, 16, 1329–1331. https://doi.org/10.1007/s00464-001-9179-2.

Higgins, J. P. T., Altman, D. G., Gøtzsche, P. C., et al. (2011). The Cochrane Collaboration’s tool for assessing risk of bias in randomized trials. BMJ, 343, d5928. https://doi.org/10.1136/BMJ.D5928

Houtsma, A., & Keuning, H. (2006). Can Augmented Force Feedback Facilitate Virtual Target Acquisition Tasks? Studies in Health Technology and Informatics, 119, 207–212.

Jacobs, S., Holzhey, D., Strauss, G., Burgert, O., & Falk, V. (2007). The impact of haptic learning in telemanipulator-assisted surgery. Surgical Laparoscopy Endoscopy & Percutaneous Techniques, 17, 402–406. https://doi.org/10.1097/SLE.0b013e3180f60c23

Jayne, D., Pigazzi, A., Marshall, H., et al. (2017). Effect of robotic-assisted vs conventional laparoscopic surgery on risk of conversion to open laparotomy among patients undergoing resection for rectal cancer. JAMA, 318, 1569. https://doi.org/10.1001/jama.2017.7219.

Jeong, I. G., Khandwala, Y. S., Kim, J. H., et al. (2017). Association of robotic-assisted vs laparoscopic radical nephrectomy with perioperative outcomes and health care costs, 2003 to 2015. JAMA, 318, 1561. https://doi.org/10.1001/jama.2017.14586

Kitagawa, M., Dokko, D., Okamura, A. M., & Yuh, D. D. (2005). Effect of Sensory Substitution on Suture-Manipulation Forces for Robotic Surgical Systems. Journal of Thoracic and Cardiovascular Surgery, 129, 151–158.

Kockerling, F. (2014). Robotic vs. standard laparoscopic technique - what is better? Frontiers in Surgery, 1, 15. https://doi.org/10.3389/fsurg.2014.00015

Kretschmer, A., Grimm, T., Buchner, A., et al. (2017). Prospective evaluation of health-related quality of life after radical cystectomy: focus on peri- and postoperative complications. World Journal of Urology, 35, 1223–1231. https://doi.org/10.1007/s00345-016-1992-2

Lamata, P., Gomez, E. J., Bello, F., Kneebone, R. L., Aggarwal, R., & Lamata, F. (n.d.). Conceptual framework for laparoscopic VR simulators. IEEE Computer Graphics and Applications, 26, 69–79. http://www.ncbi.nlm.nih.gov/pubmed/17120915 [Accessed September 25, 2018]

Lessard, J., Robert, J.-M., & Rondot, P. (1995). Evaluaton of Working Techniques Using Teleoperation for Power Line Maintenance. Proceedings – SPIE – The International Society for Optical Engineering, 88–98.

Liberati, A., Altman, D. G., Tetzlaff, J., et al. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. PLoS Medicine, 6, e1000100. https://doi.org/10.1371/journal.pmed.1000100

Minogue, J., Jones, M. G. (2006). Haptics in education: exploring an untapped sensory modality. Review of Educational Research, 76, 317–348. https://doi.org/10.3102/00346543076003317.

Niitsu, H., Hirabayashi, N., Yoshimitsu, M., et al. (2013). Using the Objective Structured Assessment of Technical Skills [OSATS] global rating scale to evaluate the skills of surgical trainees in the operating room. Surgery Today, 43, 271–275. https://doi.org/10.1007/s00595-012-0313-7

Oakley, I., McGee, M. R., Brewster, S., & Gray, P. (2000). Putting the Feel in 'Look and Feel'. Proceedings – Conference on Human Factors in Computing Systems 2000, 415–422.

Ottensmeyer, M. P., Ben-Ur, E., & Salisbury, J. K. (2000). Input and Output for Surgical Simulation: Devices to Measure Tissue Properties in Vivo and a Haptic Interface for Laparoscopy Simulators. Studies in Health Technology and Informatics, 70, 236–242.

Panait, L., Akkary, E., Bell, R. L., Roberts, K. E., Dudrick, S. J., & Duffy, A. J. (2009). The role of haptic feedback in laparoscopic simulation training. Journal of Surgical Research, 156, 312–316. https://doi.org/10.1016/j.jss.2009.04.018

Rodrigues, S. P., Horeman, T., Sam, P., et al. (2014). Influence of visual force feedback on tissue handling in minimally invasive surgery. British Journal of Surgery, 101, 1766–1773. https://doi.org/10.1002/bjs.9669

Salkini, M. W., Doarn, C. R., Kiehl, N., Broderick, T. J., Donovan, J. F., Gaitonde, K. (2010). The role of haptic feedback in laparoscopic training using the LapMentor II. Journal of Endourology, 24, 99–102. https://doi.org/10.1089/end.2009.0307

Schijven, M., & Jakimowicz, J. (2003). Virtual Reality Surgical Laparoscopic Simulators. Surgical Endoscopy, 17, 1943–1950.

Scott, I. A. (2009). Errors in clinical reasoning: causes and remedial strategies. BMJ, 338, b1860. https://doi.org/10.1136/BMJ.B1860

Sim, H. G., Yip, S. K., & Cheng, C. W. (2006). Equipment and Technology in Surgical Robotics. World Journal of Urology, 24, 128–135.

Strom, P., Hedman, L., Sarna, L. S., Kjellin, A., Wredmark, T., & Felländer-Tsai, L. (2006). Early exposure to haptic feedback enhances performance in surgical simulator training: a prospective randomized crossover study in surgical residents. Surgical Endoscopy and Other Interventional Techniques, 20, 1383–1388. https://doi.org/10.1007/s00464-005-0545-3

Ström, P., Hedman, L., Sarna, L., Kjellin, A., et al. (2006). Early Exposure to Haptic Feedback Enhances Performance in Surgical Simulator Training: A Prospective Randomized Crossover Study in Surgical Residents. Surgical Endoscopy, 20, 1383–1388.

Thompson, J. R., Leonard, A. C., Doarn, C. R., Roesch, M. J., Broderick, T. J. (2011). Limited value of haptics in virtual reality laparoscopic cholecystectomy training. Surgical Endoscopy, 25, 1107–1114. https://doi.org/10.1007/s00464-010-1325-2.Kim HK, Rattner DW, Srinivasan MA. Virtual-realitybased laparoscopic surgical training: the role of simulation fidelity in haptic feedback. Comput Aided Surg. 2004;9:227–234. https://doi.org/10.3109/ 10929080500066997.

Van Bruwaene, S., De Win, G., Miserez, M. (2009). How much do we need experts during laparoscopic suturing training? Surgical Endoscopy, 23, 2755–2761. https://doi.org/10.1007/s00464-009-0498-z van der Meijden, O. A. J., & Schijven, M. P. (2009). The value of haptic feedback in conventional and robot-assisted minimally invasive surgery and virtual reality training: a current review. Surgical Endoscopy, 23, 1180–1190. https://doi.org/10.1007/s00464-008-0298-x

van der Meijden, O. A. J., & Schijven, M. P. (2009). The value of haptic feedback in conventional and robot-assisted minimally invasive surgery and virtual reality training: a current review. Surgical Endoscopy, 23, 1180–1190. https://doi.org/10.1007/s00464-008-0298-x

Vapenstad, C., Hofstad, E. F., Langø, T., Marvik, R., & Chmarra, M. K. (2013). Perceiving haptic feedback in virtual reality simulators. Surgical Endoscopy and Other Interventional Techniques, 27, 2391–2397. https://doi.org/10.1007/s00464-012-2745-y

Wagner, C. R., & Howe, R. D. (2005). Mechanisms of Performance Enhancement with Force Feedback. First Joint EuroHaptics Conference and Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems, 21–29.

Waurick, R., Weber, T., Broking, K., Van Aken, H. (2007). The European working time directive: effect on education and clinical care. Current Opinion in Anaesthesiology, 20, 576–579. https://doi.org/10.1097/ACO.0-b013e3282f0ef61

Yiannakopoulou, E., Nikiteas, N., Perrea, D., Tsigris, C. (2015). Virtual reality simulators and training in laparoscopic surgery. International Journal of Surgery, 13, 60–64. https://doi.org/10.1016/j.ijsu.2014.11.014

Zhou, M., Tse, S., Derevianko, A., Jones, D. B., Schwaitzberg, S. D., & Cao, C. G. L. (2012). Effect of haptic feedback in laparoscopic surgery skill acquisition. Surgical Endoscopy, 26, 1128–1134. https://doi.org/10.1007/s00464-011-2011-8