Intraoperative Point of View Video Capture and Surgical Segmentation in Carpal Tunnel Release: A Feasibility Analysis

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OBJECTIVE: The purpose of this study was to (1) examine the feasibility of intraoperative point of view video while performing open and endoscopic carpal tunnel release (CTR), (2) define surgical segments of CTR, and (3) describe the duration of various surgical steps of open versus endoscopic CTR in a teaching setting.

DESIGN: Fellowship trained hand surgeons reached consensus on surgical segments for CTR. Adult patients 18 and older previously indicated for CTR in clinic were eligible. Head-mounted point-of-view cameras were worn during endoscopic and open CTR by resident surgeons. Video was reviewed to determine segment duration. Independent sample *t* tests were used for comparison of duration by technique with statistical significance set as $p < 0.05$.

SETTING: University of Iowa Hospitals and Clinics; 200 Hawkins Dr, Iowa City, IA 52242; Tertiary Academic Medical Center.

PARTICIPANTS: Orthopedic Surgery Residents and Orthopedic Surgery Faculty.

RESULTS: Surgical segments were defined as incision, dissection of superficial soft tissue structures, transection of the carpal ligament, and surgical incision closure. Twelve of 14 video capture events yielded data. In the teaching setting, the average duration of endoscopic CTR was 609.5 seconds (±111.07) versus 547.75 seconds (±82.06) for open with p value = 0.406. No surgical segments were significantly different. Transition time from dissection to ligament transection differed significantly (p = 0.004) between endoscopic (46.88 seconds ± 19.19) and open (9.0 seconds ± 7.90) CTR. Transition time between ligament transection and closure was significantly different (p = 0.029) among endoscopic (50.5 seconds ± 15.0) and open (26.25 seconds ± 2.99) CTR.

CONCLUSIONS: Point-of-view video capture is feasible for the capture of video during a common hand surgery procedure. A method for managing device battery power is necessary for future applications. CTR can be defined as, and described in, individual procedure segments potentially useful for surgical education as well as efficiency improvements. Identification of surgical segments may aid the development of better objective tools for the assessment of surgeon skill and competency for common orthopedic procedures. (J Surg Ed 76:1663−1668. © 2019 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: intraoperative POV video, orthopedic surgery, carpal tunnel release, surgical education, surgical skills assessment

COMPETENCIES: Practice-Based Learning and Improvement

INTRODUCTION

Surgeons and healthcare systems face increasing demands to efficiently utilize resources, provide high value healthcare services, and appropriately train the next generation of orthopedic surgeons.[1-3] Increasing focus on patient outcomes and quality improvements has emphasized

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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objective assessments of surgical outcomes.[4] These evolving priorities have inspired innovative approaches to surgical training, including simulation labs, and objective skills assessment tools.[2,5-7] Video-based feedback has precipitated performance gains in orthopedic surgery residents using an articular fracture trainer.[7] Further, the use of intraoperative point-of-view (POV) video can reinforce learning outside the operating room (OR) through postoperative review of acquired video.[8] Utilization of intraoperative POV video technology for assessment of time-based completion of surgical tasks has not previously been examined in CTR.

With a prevalence of 3% to 6% in the general adult population, carpal tunnel syndrome is the most common clinically diagnosed nerve entrapment syndrome with over 500,000 carpal tunnel release (CTR) procedures performed annually.[9-12] Initial treatment for carpal tunnel syndrome consists of a nonoperative approach comprised of rest, wrist orthoses that place the wrist in a neutral position, and corticosteroid injections.[9,11,13] If these treatments fail, CTR has been shown to yield satisfactory long-term symptom relief.[10,11,13] The 2 most common surgical approaches are the open CTR and the endoscopic CTR.[11,14] Open CTR employs a longitudinal incision of approximately 2 cm distal to the volar wrist crease and a few millimeters ulnar to the thenar skin crease. This allows for direct surgeon visualization and subsequent release of the carpal tunnel. Alternatively, endoscopic CTR utilizes a single portal or 2-portal incision technique in the same anatomical area as open CTR to access the structures contained within the carpal tunnel.[15] A meta-analysis by Zuo et al., revealed no difference in patient satisfaction or complication rates between the approaches. The endoscopic approach may result in less scar pain and allow patients to return to work sooner, though it may also be more expensive than an open approach.[14,16]

Innovative means by which to objectively measure surgical performance and efficiency are becoming increasingly relevant in today's healthcare environment, particularly in surgical education. For the purposes of this pilot study, the frequency of CTR, the relevance of the procedure as an Accreditation Council for Graduate Medical Education requirement in surgical training, and the fundamental skills necessary for completion of the procedure make CTR an ideal prototype for intraoperative POV video capture.[17] In the current investigation we aimed to (1) examine the feasibility and utility of resident surgeon intraoperative POV video capture while performing open and endoscopic CTR, (2) define standard surgical segments of CTR, and (3) describe trainee completion times for surgical segments of open and endoscopic CTR.

METHODS

Institutional review board approval was obtained for this investigation. Patients indicated for CTR were provided information about the study. An attending orthopedic surgeon or surgical resident completed enrollment preoperatively. On the day of surgery, all OR staff were made aware of the POV cameras (GoPro) and provided verbal consent to video recording. Before sterile preparation of the surgical field, the resident surgeon turned on the camera, assessed the battery level, and donned the POV camera using a head harness. Adjustments to the area of focus and viewing angle were done via a Wi-Fi software application on a connected smartphone device. An OR surgical technician triggered camera recording just prior to incision.

Both the open and endoscopic CTR techniques were evaluated by board certified and hand fellowship trained orthopedic surgeons and broken down into standardized surgical segments (Fig. 1). Postoperative video analysis yielded durations for these segments. Intervals between segments were defined as transitions.

Segment duration data for endoscopic and open CTRs was analyzed by independent, 2-tailed sample *t* tests based on their principles noted in the Fundamentals of Biostatistics

Procedure Segment	Description
Incision	Length of time for completion of entry incision
Transition 1	Time interval between incision completion and start of dissection
Dissection	Duration for the dissection of subcutaneous fat and palmar tissue ending in full exposure of transverse carpal ligament (TCL)
Transition 2	Time interval between the conclusion of dissection step and initial attempt to transect TCL
Ligament Transection	Total time for bisection of the TCL along distal-proximal axis
Transition 3	Time interval between finishing ligament transection and beginning closing of skin
Closure	Time elapsed to complete suturing of surgical incisions

Note: These steps apply to both Endoscopic and Open CTR

FIGURE 1. Description of the individual time segments of carpal tunnel release (CTR).

7th Edition.[18] Calculations were carried out using the SPSS 25 software pack. Alpha was set a priori to be 0.05.

RESULTS

Two second year orthopedic surgery residents and 2 hand fellowship trained orthopedic surgeons took part in the study. A total of 14 video captures were attempted on 14 consecutive patients (Average age 53 ± 12 years; 75% female) indicated for primary endoscopic or open CTR. Two attempts were excluded due to battery failure. The 12 remaining recordings consisted of 7 endoscopic and 5 open CTR procedures. Four of these remaining recordings, all endoscopic, provided only partial data because of intraoperative battery failure in 3 cases and video capture failure in 1 case (inappropriate viewing angle). Average video size was 2.81 ± 0.9 GB.

Average length of endoscopic CTR was 609.5 seconds (SD: 111.07), while open CTR was 547.75 seconds (SD: 82.06) and the difference yielded a p value of 0.406 (95% CI of difference −107.21 to 230.71). Average time duration in seconds for incision, dissection, transection of the TCL, and closure averaged 12.75 (SD: 2.49), 191.63 (SD: 49.04), 100.4 (SD:20.21), and 100.4 (SD:20.21), respectively for the endoscopic approach. Similarly, the averages in seconds for incision, dissection, transection of the TCL, and closure using the open approach were 14.0 (SD:7.57), 139.75 (SD:72.99), 200.25 (SD:94.06), and 139.75 (SD:35.59), respectively. No statistically significant differences were observed in incisional time ($p = 0.669$), dissection ($p = 0.170$), ligament transection ($p = 0.645$), and closure duration ($p = 0.073$). The transition time between incision and dissection averaged 16.38 seconds (SD: 7.41) for endoscopic CTR, 18.75 seconds (SD:15.46) for open CTR, and no statistical difference was observed ($p = 0.719$). Transition time from dissection to ligament transection averaged 46.88 seconds (SD:19.19) for endoscopic CTR relative to 9.0 seconds (SD:7.30) for open CTR and yielded a statistically significant p value of 0. 004 for difference of means. Finally, time between TCL transection and closure averaged 50.40 seconds (SD:15.0) for endoscopic CTR versus 26.25 seconds (SD:2.99) for the open approach; a significant difference between the 2 approaches ($p = 0.029$) (Table 1).

DISCUSSION

Intraoperative POV camera data acquisition in the setting of CTR was feasible in this study. However, user factors, such as headaches and technological limitations can be substantial barriers to success.[8] Although this study did not specifically address the effects on surgeons of wearing a head-mounted camera intraoperatively, prior studies by our group demonstrated that 38% of surgeons experienced headaches due to camera use.[8] Even with this problem, 88% of the surgeons still reported that the use of a head-mounted camera could be valuable to their education, and 79% were interested in obtaining a camera to document their procedures throughout their orthopedic residency.[8] The technological limitations observed in this study were primarily due to battery management, which resulted in data loss or video capture failure that affected 40% of video acquisition attempts.

Previously reported barriers, such as large video files, wide angle lens video distortion, and challenges with adjusting camera focus were not problematic in this investigation thanks to improvements in camera technology that allowed for improved camera setup.[19] While this study did not formally assess video quality, exceptional video quality, minimal viewing obstructions, and negligible distortion were anecdotally noted during review of intraoperative videos for surgical segment duration. Additional barriers to the use of intraoperative camera technology, including objections by surgical support staff and privacy concerns by perioperative staff as reported in previous investigations, did not occur in this study.[8] Institutions implementing intraoperative video acquisition should dedicate resources appropriately and plan for third party monitoring of battery consumption both during and between

TABLE 1. Time of Carpal Tunnel Release (CTR) by Segment

Procedure Step	Endoscopic CTR (Time in Seconds)	Open CTR (Time in Seconds)	Independent Samples *t* Test p Value
Incision	12.75 ± 2.49	14.0 ± 7.57	0.669
Transition 1	16.38 ± 7.41	18.75 ± 15.47	0.719
Dissection	191.63 ± 49.04	139.75 ± 72.99	0.170
Transition 2	46.88 ± 19.19*	9.0 ± 7.90*	0.004 *
Ligament transection	222.14 ± 60.09	200.25 ± 94.06	0.645
Transition 3	50.40 ± 15*	26.25 ± 2.99*	0.029 *
Closure	100.4 ± 20.21	139.75 ± 35.59	0.073
Total procedure length	609.50 ± 111.07	547.75 ± 82.06	0.406

* Significant difference in time between Endoscopic CTR and Open CTR.

procedures so that fully charged batteries are readily available. Lengthy surgical procedures may require the use of replacement batteries.

Intraoperative POV video is a potentially important adjunct to existing surgical education assessments.[2,20] Existing procedural assessments, such as the Objective Structured Assessments of Technical Skills, are inconsistent in assessing competency and predicting surgical outcomes.[6,21] Routine use of POV camera recordings could provide valuable material for postoperative surgical skills assessments, by providing consistent data points for back-to-back comparison of specific tasks and segments in a standardized way.[8,21] Intraoperative POV video acquisition is unobtrusive, cost effective, and of high visual quality.[19] POV camera technology can also provide favorable, unobstructed imagery of the surgical field that junior trainees may not always adequately visualize, which is a substantial improvement over other intraoperative video capture methods.[19] Alternative technologies further suffer from other shortcomings, such as surgical field washout by bright OR lights, and the need for expensive, sometimes obtrusive OR equipment that may require specialized expertise for flawless use.[19] Because of their greater ease of use and capability to allow educators to both establish and analyze standardized surgical segments, intraoperative POV videos could provide the infrastructure for future objective assessments.

A previous study reported that 88% of orthopedic surgery residents surveyed felt that intraoperative POV video capture and a corresponding video portfolio of procedures added value to their education.[8] Even though this study did not evaluate the use of intraoperative video as a teaching tool, we report that the technology utilized allows for easy distribution of captured videos to trainees seeking supplemental learning materials. Consequently, videos could be reviewed by the resident surgeon alone or with faculty outside of the higher-pressure environment of the OR, so educators could provide specific feedback and allow time for reflection.[7] Additionally, reviewing intraoperative videos with faculty may help address possible concerns regarding a resident's competency and reliability for performing milestone procedures.[22] A shared library of intraoperative POV recordings could provide a wealth of data for institution-specific procedural learning, but the extended time required to edit and further prepare videos may be too large of an obstacle for busy trainees to overcome.[23] Indeed, we recommend that video libraries focus on common, well-established, and described procedures like open and endoscopic CTR, as these would be the most relevant and likely to benefit trainees during their surgical education. Eventually, with appropriate privacy safeguards, video libraries could also be shared among institutions, encouraging technical discourse within the specialty.

In this investigation, we defined segments of open and endoscopic CTR (Fig. 1). By defining segments, inefficient or deficient skills in a specific segment, such as dissection or transection of the TCL, can be more easily identified by educators for review and reinforcement. Studies like the present work that define surgical segments are important for the development of improved objective orthopedic procedure assessment tools, which will become increasingly critical in light of trends towards competency-based medical education.[22] Moreover, establishment of these surgical segments may create the foundation for educations to develop high-yield teaching videos of ideal length and content for trainees, which has been discussed in other works.[23] Video capture with procedure segmentation also opens the door to strategies like crowd-sourcing, where economical online crowd workers could be employed to grade technical aptitude across large volumes of data.[24] This strategy has demonstrated preliminary equivalence compared to faculty surgeons' assessments.[24]

Previous reports note that surgeon skill levels may determine the time to complete various surgical tasks.[25] A study by Birkmeyer et al. utilizing a modified version of the Objective Structured Assessments of Technical Skills for review of intraoperative bariatric surgery video noted that videos receiving higher scores (a surrogate for rating surgeon skill) correlated with a surgeon's procedure volume.[26] In contrast, this study sought to describe the average duration of each segment of CTR and did not evaluate surgeon performance. To our knowledge, no prior work has previously utilized this method or measured the duration of surgical segments in trainees performing CTR. While overall procedure durations and individual steps were not significantly different between endoscopic and open techniques, the endoscopic transitions between dissection and TCL transection and between TCL transection and closing were significantly longer. This is likely attributable to manipulation, repositioning, and endoscope removal. For procedures of greater duration and complexity, differences in segment and transition duration may help to identify surgical inefficiencies. Differences in segment duration among trainees may facilitate prompt identification of skill deficiencies.

This study had several limitations. First, the initial cohort was small in number and was further limited by equipment failures. Thus, it is possible that the average reported time values for each step may be substantially different when a greater number of trainees are included. Second, the project was carried out at a single institution and thus our findings may not be generalizable. Finally, success of video capture was impacted by user error and hardware limitations as discussed previously.[8]

CONCLUSION

POV video capture is feasible in the setting of CTR. Special attention must be given to battery management. Surgical segments of CTR are identified as incision, dissection of superficial soft tissue structures, transection of the TCL, and surgical incision closure. In the teaching setting, no significant differences were identified between open and endoscopic CTR segment durations. The transition times between surgical segments in endoscopic CTR tend to be longer than open CTR and present an opportunity for potential efficiency improvements. Identification of surgical segments may aid the development of better objective tools for the assessment of surgeon skill and competency for common orthopedic procedures.

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SUPPLEMENTARY INFORMATION

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.jsurg.2019.06.004.