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Expert surgeons' conceptualisation of tissue tension management: a qualitative study across three surgical specialties

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Research Article

Keywords: surgical expertise, qualitative research, countertraction, tissue tension management, tacit knowledge, surgical data science, surgical education, intraoperative teaching

Posted Date: November 18th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11316616/v1

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Additional Declarations: No competing interests reported.

Abstract

Background

Controlling tissue tension is a fundamental intraoperative manoeuvre; however, much of the knowledge that guides it remains tacit, and no shared framework exists to describe how experts perceive and adjust it. Consequently, this skill is difficult to teach and assess; intraoperative teaching is often limited to fragmentary instructions, and assessment tools capture observable movements but not the cognition behind them. This study aimed to clarify how expert surgeons control tissue tension and to develop a cross-specialty conceptual framework to support teaching and assessment.

Methods

Board-certified surgeons who had performed at least 500 operations as the primary surgeon in head and neck surgery, gynaecological oncology, or gastrointestinal surgery were purposively recruited from multiple institutions in Japan. Three in-person focus groups, one per specialty, were conducted between May 2024 and September 2025, using countertraction as the starting point for discussion. Verbatim transcripts were analysed inductively using reflexive thematic analysis, both within and across specialties.

Results

Twenty-two surgeons participated (seven head and neck surgeons, seven gynaecological oncologists, and eight gastrointestinal surgeons), yielding 520 meaning units. Tension management emerged as a higher-order concept encompassing traction, retraction, triangulation, exposure, and collaboration with assistants. It comprises three layers: WHY (principles: safety, efficiency, and collaboration), HOW (judgement: situational reading and adaptive decision-making), and WHAT (execution: traction point, direction, and magnitude). Changes in the operative field and tissue responses after execution prompted a cyclical recalibration of judgement. The same structure was identified in all three specialty groups, with differences between specialties appearing mainly in the conditions interpreted through situational reading, such as anatomy, tissue characteristics, devices, and platforms.

Conclusions

Among expert surgeons, tissue tension management was organised as a WHY-HOW-WHAT cognitive–operative process that links principles, judgement, and execution. This framework provides a cross-specialty process language for tacit surgical skills and a conceptual basis for relating observable performance measures to the cognition behind them. Both applications require validation in educational settings and against intraoperative data.

Background

Surgeons perform much of the intraoperative dissection and division while grasping and retracting tissue to generate appropriate tension. Generating, adjusting, and using this tension—commonly referred to as countertraction, among other terms—constitute a fundamental intraoperative manoeuvre, and how well it is performed directly affects surgical quality, including the extent of bleeding, the avoidance of injury to surrounding organs and nerves, and the reliability of dissection. However, much of the knowledge that supports this manoeuvre remains tacit, and during intraoperative teaching, it tends to be compressed into context-dependent, fragmentary instructions, such as ‘pull more’, ‘hold there’, or ‘change the angle’. Because no shared framework for expressing the control of tissue tension has been established, surgeons and assistants find it difficult to share a common understanding of the operative field, and tension management is difficult to teach and assess.

Surgeons’ technical skills are associated with patient outcomes [1], and structured technical assessment methods, such as the Objective Structured Assessment of Technical Skill (OSATS) [2], have been used to evaluate intraoperative performance. More recently, automated analyses of surgical video and instrument kinematics have also been investigated [3, 4]. However, these approaches assess observed performance without explaining, at the process level, the underlying cognitive skills (e.g. situation awareness and decision-making) or the operative adjustments that produce this performance [5]. As intraoperative motion analysis advances, a conceptual framework that links observable movements to the reasoning that guides them is increasingly needed [3].

In a previous study, we verbalised and categorised the fundamental surgical skills required for open head and neck surgery and showed that countertraction is a skill category with high educational priority, given both its importance and the difficulty of acquiring it [6]. However, that study did not clarify the cognitive–operative process by which expert surgeons perceive and adjust tissue tension during surgery, or whether this process is shared across specialties with different anatomical backgrounds and operative-field environments. If a structure common to multiple specialties exists, it could serve as a cross-specialty framework for describing intraoperative processes beyond procedure- or field-specific rules of thumb.

Therefore, we conducted a cross-specialty qualitative study of expert surgeons in head and neck surgery, gynaecological oncology, and gastrointestinal surgery, using countertraction as a starting point for discussion. The objective of this study was to clarify the cognitive–operative process by which expert surgeons control tissue tension, a process that underlies observable surgical performance, and to present it as a cross-specialty conceptual framework to support teaching and assessment.

Methods

Study design and epistemological position

This cross-specialty qualitative study used focus groups. We adopted a contextualist position [7, 8], assuming that the cognitive–operative process underlying expert surgeons' control of tissue tension is real, while treating the data as constructed and interpreted through the interactive setting of the focus group and the linguistic and clinical contexts of participants and researchers. Expert surgeons' practical knowledge of controlling tissue tension is largely tacit and is not only held individually but also shared and shaped through clinical experience and interaction with other surgeons. Therefore, we used focus groups [9] rather than individual interviews. Interaction among participants—agreement, disagreement, and elaboration—promotes the recall of concrete experiences and the comparison of views, allowing tacit judgement to be expressed more richly and enabling the commonalities and differences in this shared knowledge across specialties to be examined. The research team's clinical experience was treated not as a bias to be eliminated but as a resource for interpreting tacit knowledge, subject to the safeguards described below. Focus groups, transcription, coding, and analysis were conducted in Japanese to preserve the contextual and idiomatic meanings of the participants' accounts. For publication, translations into English prioritised the intended clinical and conceptual meanings over literal rendering, and all representative quotations were checked against the original Japanese transcripts. This study is reported in accordance with the Standards for Reporting Qualitative Research (SRQR) [10] (Additional file 1).

Participants and sampling

Expert surgeons, defined as board-certified surgeons who had performed at least 500 operations as the primary surgeon in their specialty, were recruited by purposive sampling from multiple teaching hospitals, core hospitals, and cancer centres in Japan across three specialties: head and neck surgery, gynaecological oncology, and gastrointestinal surgery. These specialties differ in anatomical background, operative environment, tissue characteristics, and surgical platform, yet all routinely involve grasping, retracting, dissecting, and dividing tissue; they were therefore judged suitable for examining a structure independent of any particular specialty or procedure. Participants were selected to ensure diversity in procedures and platforms, including open, laparoscopic, endoscopic, and robotic surgery. The sample size was not determined statistically. Each group was planned to include approximately five to eight participants, based on established recommendations for focus group research [11], a size that encourages discussion while allowing each participant to contribute adequately. Conducting one focus group per specialty was a pragmatic decision aligned with the objective of comparing accounts across the three specialties.

Data collection

Three focus groups, one per specialty, were conducted in person in Japan between May 2024 and September 2025, each scheduled to last one to two hours. All groups were moderated by the same researcher (S.M.), a head and neck surgeon experienced in medical education research and focus group moderation, who used the same semi-structured interview guide developed from the study objective and

our previous study[6] (Additional file 2). No analytical framework or definitions of terms were provided in advance, and participants described their experiences in their own words. Countertraction was used as the starting point to help participants recall concrete experiences; the main questions addressed the manoeuvres the term brought to mind, its role in surgery, its ideal state, key points in achieving it, and how the skill was acquired. Follow-up questions addressed the following topics when they were not raised spontaneously: the division of roles between the surgeon and assistant, the use of both hands, devices, procedures, surgical platforms, points of caution, and teaching. The moderator had no prior teaching, supervisory, or evaluative relationship with participants in gynaecological oncology or gastrointestinal surgery, but had existing professional relationships, including hierarchical ones, with some head and neck surgery participants; the moderator was not involved in any evaluation related to participants' employment, promotion, or certification. The sessions were audio-recorded with the participants' consent.

Data analysis

Recordings were transcribed verbatim, and reflexive thematic analysis was conducted according to Braun and Clarke [7, 8]. The analysis was not limited to statements containing the word 'countertraction' but encompassed all statements about situations in which tissue tension was generated, adjusted, or used, including grasping, retracting, exposing, dissecting, and dividing tissue, creating the operative field, manipulating devices, and collaborating with an assistant. When discussions touched on skill acquisition and teaching, content revealing the purpose of tension, cues for judgement, or operative adjustments was analysed; however, teaching methods were not examined as a separate research question. Transcripts were read repeatedly and divided into meaning units, and initial codes were assigned inductively with reference to the surrounding context, rather than to a predefined classification scheme. Within each specialty, similar codes were consolidated into provisional categories and themes; codes and themes were then compared across the three specialties to identify common elements and specialty-specific contexts. Within-specialty analysis and cross-specialty comparisons were performed iteratively to generate the theme structure that most coherently explained the data as a whole. Coding and data management were performed using spreadsheet software (Microsoft Excel; Microsoft Corp., Redmond, WA, USA).

Rigour and reflexivity

The research team included practising surgeons in each of the three specialties and researchers specialising in surgical education and qualitative methodology. Because the surgeons' clinical experience and intraoperative schemas could shape interpretation, several safeguards were applied. Primary coding of all transcripts was performed by one researcher (S.M.) to ensure continuous engagement with the entire dataset. Codes, candidate themes, and the relationships among them were examined iteratively by a team comprising a head and neck surgeon (S.M.), a gynaecological oncologist (K.K.), a gastrointestinal surgeon (S.P.), and a non-surgeon qualitative researcher (T.K.); the aim was not

to calculate intercoder agreement or reach a single correct code but to challenge interpretations from different professional standpoints. Interpretations were repeatedly checked against the transcripts and the surrounding context of each statement. Interpretations of the head and neck group, the moderator's own specialty, were compared with those of the other two specialties and discussed with researchers from those specialties. The non-surgeon researcher's participation ensured that assumptions tacitly shared among the surgeons were examined before they could influence theme generation. Each theme was verified against representative quotations and by examining both accounts specific to a single specialty and statements that did not fit the provisional themes. Member checks were not performed.

Ethics and data management

This study was approved by the Ethics Review Committee of Ehime University (registration number 2402007). The participants were informed of the purpose of the study, the content of the focus groups, audio recording, data use, the voluntary nature of participation, and the absence of any disadvantage for declining. Written informed consent was obtained from all participants. Attribute information (specialty, experience, and main surgical platform) was retained for analysis, whereas identifying details in representative quotations were removed or generalised so that surgeons and institutions could not be identified. The data were stored in an environment accessible only to the research team.

Use of generative artificial intelligence

During manuscript preparation, the authors used Claude (Anthropic; Claude Fable 5.1 and earlier versions, accessed via claude.ai between May and October 2026) to improve text readability and language. The authors reviewed and edited all content and take full responsibility for the content of the publication.

Results

Participant characteristics and focus group data

Twenty-two expert surgeons participated: seven head and neck surgeons, seven gynaecological oncologists, and eight gastrointestinal surgeons. From the focus group transcripts, 520 meaning units related to tissue tension control were extracted. Participant characteristics, the duration of each focus group, and the number of meaning units by specialty are presented in Table 1.

Table 1
Characteristics of the participants and focus group sessions

Characteristic	Head and neck surgery (n = 7)	Gynaecological oncology (n = 7)	Gastrointestinal surgery (n = 8)
Demographics			
No. of participants	7	7	8
Age, median (range), y	43 (38–55)	46 (39–49)	49 (36–58)
Sex, male/female, No.	7/0	6/1	7/1
Years since graduation, median (range)	19 (14–31)	20 (15–24)	23.5 (11–34)
Years of specialty experience, median (range)	17 (12–31)	18 (13–24)	22 (10–34)
Surgical background			
Board certification, No. (%)	Otorhinolaryngology– Head and Neck Surgery, 7 (100) Head and Neck Oncology, 7 (100)	Obstetrics and Gynaecology, 7 (100) Gynaecologic Oncology, 7 (100)	Surgery, 8 (100) Gastroenterological Surgery, 7 (88) American Board of Surgery, 1 (13)
Annual surgical volume, No. (%)			
≥ 100 cases	5 (71)	4 (57)	3 (38)
50–99 cases	0 (0)	3 (43)	4 (50)
10–49 cases	0 (0)	0 (0)	0 (0)
5–9 cases	2 (29)	0 (0)	1 (13)
Cumulative surgical volume, No. (%)			
≥ 500 cases	7 (100)	7 (100)	8 (100)
Surgical approach experience (multiple responses allowed), No. (%)			
Open	7 (100)	7 (100)	8 (100)
Laparoscopic/endoscopic	5 (71)	7 (100)	8 (100)
Robotic	3 (43)	7 (100)	5 (63)

Percentages for board certification may total more than 100% because participants could hold multiple certifications. —, not applicable.

Characteristic	Head and neck surgery (n = 7)	Gynaecological oncology (n = 7)	Gastrointestinal surgery (n = 8)
Demographics			
Subspecialty (gastrointestinal surgery only), No. (%)	—	—	Upper gastrointestinal, 2 (25) Lower gastrointestinal, 3 (38) Hepatobiliary-pancreatic, 2 (25) Surgical oncology, 1 (13)
Focus group session			
Date	24 May 2024	15 November 2024	21 September 2025
Duration, min	108	77	109
Format	In-person	In-person	In-person
Meaning units included in the analysis, No.	146	173	201

Percentages for board certification may total more than 100% because participants could hold multiple certifications. —, not applicable.

Development and structure of the tension management concept

Although countertraction was the starting point for discussion, participants spoke about a broad range of manoeuvres, including traction, retraction, triangulation, exposure, and collaboration with the assistant, and described these not as separate techniques but as a single, purposeful process of generating and adjusting tissue tension. We therefore adopted ‘tension management’ as a superordinate concept encompassing these manoeuvres. The analysis organised tension management as a three-layer cognitive–operative process comprising WHY (principles), HOW (judgement), and WHAT (execution). The principles (why tension is applied) comprise safety, efficiency, and collaboration; judgement (how the required tension is determined) comprises situational reading and adaptive decision-making; and execution (what is concretely performed) comprises the traction point, direction, and magnitude. The structure is illustrated in Fig. 1, the definitions of each component are provided in Table 2, and representative quotations by specialty are presented in Table 3.

Table 2
Definitions of themes, subthemes, and codes in the WHY-HOW-WHAT framework of tension management

Theme	Subtheme	Code	Definition
WHY (Principles)	a. Safety: perception of anatomical structures and avoidance of harm	Enhancing the visibility of critical structures to be preserved	Making anatomical landmarks, such as embedded nerves, vessels, and luminal structures, stand out from the surrounding background to prevent misidentification.
		Securing a safety margin from the critical structures to be preserved	Pulling in an appropriate direction to physically distance critical structures from the dissection line, creating a visual and physical buffer that prevents unintended thermal or mechanical injury.
		Clarifying the dissection line and dissection plane	Clearly presenting the anatomically correct path to follow once a safety margin has been secured.
	b. Efficiency: biomechanical optimisation through physical shaping of tissue	Improving the efficiency of dissection itself	Applying appropriate tension to accentuate the density gradient of fine fibres, reducing the cutting resistance for energy devices or scalpels and achieving efficient division.
		Improving device manoeuvrability in the operative field	Optimising the approach angle of devices through traction and physically creating and maintaining an operating space that prevents interference with surrounding tissue or between instruments.
	c. Collaboration: synchronisation of operative-field awareness through shared understanding	Shared understanding and communication within the team	Sharing the blueprint of tension—where, how strongly, and in which direction to pull—between the operator and assistant, and reaching a shared understanding that the team is jointly creating a single effective exposure.
HOW (Judgement)	a. Situational reading: reading anatomy, tissue, devices, platform, and the assistant to determine the range within which tension can be applied	Reading anatomical properties	Reading the extensibility, fragility, fixation, and mobility of tissue to determine where, in which direction, and how strongly it can be pulled.
		Reading device and platform constraints	Reading the characteristics of the surgical approach (open, laparoscopic, or robotic) and of the devices in use (e.g.

Theme	Subtheme	Code	Definition
			monopolar or advanced bipolar energy devices) to determine the feasible range of, and precautions for, applying tension.
		Reading the assistant's capability	Reading the assistant's skill and movements to determine how the work of traction can be divided between the surgeon and assistant.
	b. Adaptive decision-making: ongoing judgement of the tension a moment requires, revised as the operative field changes	Control of appropriate tension	Selecting and maintaining the optimal magnitude of tension that maximises manoeuvrability and visibility without causing tissue injury (laceration or ischaemia), accounting for tissue elasticity and fragility.
		Dynamic and sequential adjustment	Continuously reassessing the required traction point (anchor) and direction in real time in response to moment-to-moment changes in tissue slack and resistance as dissection proceeds.
WHAT (Execution)		Traction point	The physical point at which the tissue is grasped and pulled with forceps or similar instruments to generate appropriate tension.
		Traction direction	The direction in which traction force is applied relative to a fixed point to develop a plane or layer.
		Traction magnitude	The amount of tension applied to obtain the necessary exposure and division while avoiding tissue injury.

Table 3
Representative quotations illustrating the framework across specialties

Theme/subtheme/code	Head and neck surgery	Gynaecological oncology	Gastrointestinal surgery
WHY (Principles)			
a. Safety			
Enhancing visibility of critical structures	*'When you apply countertraction and things move, the anatomy comes into view.' (HNS-4)*	*'With the right amount of tension, even the perforating vessels become fully visible.' (GYN-2)*	*'When tension is applied, the anatomy is laid bare—it becomes easier to see.' (GIS-8)*
Securing a safety margin from critical structures	*'If you can create space on the far side, the forceps go in more easily.' (HNS-4)*	*'With good traction you create space and gain distance from the vessels.' (GYN-4)*	*'We tape the vessels, pull firmly, and go in to cut at a point well away from them.' (GIS-6)*
Clarifying the dissection line and plane	*'You watch for where one layer changes into the next.' (HNS-2)*	*'You apply tension to the loose, frothy layer and divide plane after plane.' (GYN-5)*	*'The main aim is to pull the membranous tissue three-dimensionally so the loose areas become easy to see.' (GIS-8)*
b. Efficiency			
Improving the efficiency of dissection	*'You cannot cut unless the tension is up; it is essential for cutting.' (HNS-6)*	*'Where tension is not established, you cannot cut.' (GYN-4)*	*'Without tension, the electrocautery simply will not divide the tissue.' (GIS-2)*
Improving device manoeuvrability	*'It is about creating the most workable environment for manipulation.' (HNS-2)*	*'The aim is to set the stage—to create the operative field.' (GYN-1)*	*'Traction sets the field; once it is stabilised, you apply countertraction and cut.' (GIS-3)*
c. Collaboration			
Shared understanding and communication	*'An assistant cannot hold well without knowing where you intend to cut; you grasp the rationale and stay a step ahead.' (HNS-3)*	*'When I give good traction as the assistant, the operator cuts exactly where I want them to.' (GYN-3)*	*'By applying traction to reveal the dissectible layer, you can show even students where the cutting line is.' (GIS-2)*
HOW (Judgement)			

Representative quotations were translated from Japanese into English, with priority given to preserving their clinical and conceptual meanings. The research team reviewed and refined the translations against the original Japanese transcripts. HNS, head and neck surgery; GYN, gynaecological oncology; GIS, gastrointestinal surgery.

Theme/subtheme/code	Head and neck surgery	Gynaecological oncology	Gastrointestinal surgery
WHY (Principles)			
a. Safety			
a. Situational reading			
Reading anatomical properties	*'In the tongue, the line shifts as you pull, so you must cut with that in mind.' (HNS-1)*	*'The uterus is anchored within the pelvis, so the principle is to pull against its fixed point.' (GYN-3)*	*'Cutting connective tissue is somewhat different from cutting an organ or firm tissue such as peritoneum.' (GIS-5)*
Reading device and platform constraints	*'With a device like LigaSure, too much tension makes it cut before it seals.' (HNS-6)*	*'With the robot I can apply it myself, controlling both hands as my own, which makes it easier.' (GYN-3)*	*'In laparoscopy you simply cannot pull the deep part towards you.' (GIS-4)*
Reading the assistant's capability	*'If the assistant is not skilled, I just have them hold the tissue fixed and apply the countertraction myself against that.' (HNS-2)*	*'You have to be able to operate whoever the first assistant is, so if the assistant is not good, I pull firmly myself and get on with it.' (GYN-6)*	*'Even with the matador manoeuvre, a skilled assistant would keep lifting the tissue higher and higher.' (GIS-2)*
b. Adaptive decision-making			
Control of appropriate tension	*'With the internal jugular vein, pulling too hard obscures it; you want just enough that the branches show and it can still be divided.' (HNS-3)*	*'Because you are pulling under tension, the unseen tissue deep to it can tear.' (GYN-3)*	*'Appropriate tension is crucial; pull too hard and the loose froth collapses and becomes hard to read.' (GIS-1)*
Dynamic and sequential adjustment	*'Once it is divided I move again, controlling things so I am always cutting at the point of maximal tension.' (HNS-1)*	*'Once you cut, that tension is released and a different view appears.' (GYN-2)*	*'Once you start cutting, the tension keeps changing, but you maintain it throughout.' (GIS-5)*
WHAT (Execution)			
Representative quotations were translated from Japanese into English, with priority given to preserving their clinical and conceptual meanings. The research team reviewed and refined the translations against the original Japanese transcripts. HNS, head and neck surgery; GYN, gynaecological oncology; GIS, gastrointestinal surgery.			

Theme/subtheme/code	Head and neck surgery	Gynaecological oncology	Gastrointestinal surgery
WHY (Principles)			
a. Safety			
Traction point	*'My basic style is to hold the side opposite the first assistant and cut.' (HNS-1)*	*'Our organs are fixed to the retroperitoneum, so pulling at two points achieves triangulation.' (GYN-6)*	*'With two near points and a fixed far point you have three; pulling the near point brings out the tension here.' (GIS-5)*
Traction direction	*'When force is applied in one direction, you apply equal tension in the opposite direction.' (HNS-2)*	*'To pull the round ligament, countertraction means pulling opposite to where it attaches.' (GYN-6)*	*'Pulling in opposing vectors to develop a plane or layer—that is countertraction.' (GIS-4)*
Traction magnitude	*'Pull too hard and it gets harder to see; ease off slightly and the cord-like structure springs into view—but too weak and it will not cut.' (HNS-2)*	*'There are two kinds: a large traction that grossly retracts, such as lifting the uterus, and a small one added just as you go in to cut.' (GYN-3)*	*'Open it too wide and the loose connective froth collapses; too narrow and you are left peering in.' (GIS-3)*

Representative quotations were translated from Japanese into English, with priority given to preserving their clinical and conceptual meanings. The research team reviewed and refined the translations against the original Japanese transcripts. HNS, head and neck surgery; GYN, gynaecological oncology; GIS, gastrointestinal surgery.

WHY (Principles)

The WHY layer comprises three principles that guide tension management: safety, efficiency, and collaboration. These principles were identified in the accounts of all three specialty groups and guided the participants' judgements regarding how tissue tension should be applied.

Safety was regarded as the most fundamental principle. Appropriate tension was said to make anatomical structures easier to see, secure distance and a safety margin from critical structures, and clarify the dissection plane and division line. One gynaecological oncologist stated that applying the right amount of tension makes even fine structures, such as perforating vessels, visible (GYN-2, Table 3).

Efficiency referred to the principle of advancing dissection and division smoothly. Applied tension modulates the physical resistance to cutting with energy devices or a scalpel, affects device entry and manoeuvrability, and reduces wasted movement while maintaining operative flow.

Collaboration referred to the principle by which surgeons and assistants share a common understanding of the operative field. Participants described retraction as a means of communicating where one is

looking and where one intends to dissect or divide, which positions tension management as a team-based process rather than an individual skill.

HOW (Judgement)

The HOW layer comprises the judgements through which the principles guide the configuration of tension in a given situation. It has two components: situational reading, which establishes the possibilities and constraints for applying tension, and adaptive decision-making, which determines the tension required within those constraints.

Situational reading involves interpreting anatomical and tissue properties as well as device and platform constraints. Participants considered tissue fixation, mobility, fragility, and extensibility, together with the access and movements permitted by the procedure and platform. The assistant's capability was read as an additional condition, and how the surgeon adjusted and shared traction with the assistant depended on the assistant's experience. One gastrointestinal surgeon noted that, unlike in open surgery, deep tissue sometimes cannot be retracted in the intended direction in laparoscopic surgery (GIS-4, Table 3).

Adaptive decision-making involves selecting and revising the tension required at a given moment, including judgements about the traction point, direction, and magnitude. These decisions are informed by situational reading and guided by safety, efficiency, and collaboration. Excessive or insufficient tension can compromise the operative field or dissection plane. Because tissue fixation and visibility changed as the dissection proceeded, surgeons continually reassessed the required tension and adjusted it accordingly.

WHAT (Execution) and cyclical recalibration

The WHAT layer comprises the operative variables through which the tension determined in the HOW layer is executed. The traction point concerned where to grasp and what to use as a fulcrum. The participants combined multiple points to distribute or concentrate tension, and one head and neck surgeon described holding the side opposite to the first assistant as a basic approach (HNS-1, Table 3). The traction direction concerned the direction of pull, which was adjusted according to the fixation points, dissection plane, division line, and device entry angle. The traction magnitude concerned the amount of force used, ranging from gross traction to expose the entire field to fine traction applied just before division.

Participants described tension management as a cyclical process in which changes in the operative field and tissue responses following execution inform subsequent judgements (Fig. 1). Surgeons continually revised their decisions regarding traction in response to these changes. One gastrointestinal surgeon described using the appearance of the tissue as a cue to judge whether to retract further (GIS-4). When appropriate tension could not be obtained, or when the dissection moved to a different anatomical region or operative phase, the surgeons reconsidered the conditions on which their decisions were based. This involved revisiting the situational reading to reassess how tension could be applied; one

head and neck surgeon noted that the appropriate tension differed depending on the target tissue (HNS-1).

Cross-specialty convergence

A common higher-order structure of tension management was observed across the three specialties, whereas the accounts within each specialty reflected its particular anatomical and technical context. Head and neck surgeons described the precise adjustment of tension within a narrow operative field containing nearby critical structures such as nerves and vessels, while gynaecological oncologists described fixed pelvic structures, as well as the traction direction, space formation, and platform constraints specific to laparoscopic and robotic surgery. Gastrointestinal surgeons described field formation using membranous structures, dissectible planes, and the mobility of organs and mesenteries. Despite these specialty-specific features, the statements of each specialty corresponded to the same WHY-HOW-WHAT structure; what varied between specialties was located primarily within one component of the HOW layer, situational reading, rather than within the cognitive–operative process itself.

Discussion

Overall, this study showed that, among expert surgeons, tissue tension management during intraoperative dissection is not mere retraction but a cognitive–operative process. The principles of safety, efficiency, and collaboration (WHY) are pursued by making judgements based on the anatomical conditions, tissue characteristics, devices, platform constraints, the assistant's capability, and intraoperative changes in tension (HOW). These judgements are then executed as traction point, direction, and magnitude (WHAT). This structure was identified in all three specialty focus groups. Tension management thus emerged as a higher-order concept encompassing traction, retraction, triangulation, exposure, and collaboration with assistants.

An important contribution of this study is that it presents the intraoperative management of tissue tension, which has long been recognised by surgeons as important [6] yet has remained tacit, as a shareable process language. Experts perform much of their work automatically and, when teaching, often omit the decisions that guide their actions [12]. Cognitive task analysis [13, 14] has been used to make tacit judgement explicit but has focused mainly on procedure-specific knowledge. In contrast, this study focused on a cognitive–operative process shared across specialties and presented it as a WHY-HOW-WHAT structure. Within this structure, the three principles of the WHY layer must be maintained throughout the operation; however, in practice, they are often constrained by situational factors, including anatomy, devices, platforms, and assistants. Reading these constraints constitutes the situational reading of the HOW layer, and adaptive decision-making operates within the range they allow. Only on the basis of this judgement is the WHAT layer executed and the actual tension generated in the tissue.

From an educational perspective, this framework may serve as a conceptual basis for connecting performance assessments to concrete intraoperative feedback. In intraoperative teaching, fragmentary

instructions such as ‘pull more’ or ‘change the angle’ address only the WHAT layer, whereas the framework also makes explicit the principle at stake (WHY) and the cues to read (HOW). This may allow a supervising surgeon to provide instructions about the traction point, direction, or magnitude by linking them to what is to be achieved in that situation and to what should be read from the operative field. Conversely, learners can ask which layer an unclear instruction concerns and what is expected at that layer. Recent work on implementing performance metrics in training has emphasised that such metrics must be interpreted in context [15]. The framework may thus offer a common language for interpreting assessments of tension management in relation to the underlying judgements and principles, and for making teaching more specific.

As these examples illustrate, the framework distinguishes the externalised operative layer from the cognition that directs it. The traction point, direction, and magnitude of the WHAT layer can be observed and quantified through surgical videos and instrument kinematics [3, 4], and structured rating scales, such as OSATS [2], likewise assess observable performance. By contrast, the WHY and HOW layers comprise the principles and judgements behind an operation, which are difficult to infer from observed movements alone. Nevertheless, operative metrics extracted from videos of the surgical field were recently shown to be associated with expert ratings of situation awareness and decision-making, suggesting that observable operations can serve as cues for inferring cognitive skills [5]. The present framework may provide a lens for rating videos of tension management by mapping observed operations onto the underlying cognitive skills, rather than rating the operations alone. Surgical data science has emphasised the need for models that explicitly describe surgical actions [16], and annotation schemes and rating criteria based on this framework may inform the development of artificial intelligence-assisted video assessments, although this remains to be validated.

Collaboration was identified as a principle of tension management, indicating that the process extends beyond individual technique to a shared understanding of the operative field within the team. Moreover, the extent to which this principle is realised at a given moment is determined in the HOW layer; situational reading includes the assistant’s capability, and adaptive decision-making distributes the work of traction accordingly. Tension management thus encompasses the relationship between the surgeon and assistant, who together accomplish exposure, dissection, and division. Teamwork and communication in the operating theatre are important components of non-technical skills [17], and a shared mental model is regarded as a prerequisite for a complex surgical team to function effectively [18, 19]. Tension management can, therefore, be understood as a collaborative cognitive–operative process, one that is a technical skill yet also incorporates elements of non-technical skills.

The WHY-HOW-WHAT structure was identified in all three specialty focus groups, suggesting that tension management is not a technique specific to a particular procedure or specialty but an intraoperative process carried out through exposure, dissection, and division while grasping and retracting tissue. The applied tension differs according to the anatomical conditions, tissue characteristics, devices, access, field of view, instrument degrees of freedom, and the assistant’s capability. In this framework, these differences across specialties, procedures, and platforms are

interpreted as differences in the situational reading of the HOW layer rather than in the structure itself. As surgery becomes increasingly minimally invasive, robotic, and digital, framing the changes brought about by new devices and platforms as changes in situational reading may allow their effects on tension management to be understood systematically, providing a common reference in an evolving surgical environment.

This study has several limitations. First, the study was conducted among expert surgeons in Japan; the local culture of surgical education, team composition, and style of intraoperative communication may have influenced the results. Second, the specialties studied were limited to head and neck surgery, gynaecological oncology, and gastrointestinal surgery. Whether these findings extend to other fields, such as orthopaedic surgery, neurosurgery, and urology, remains unknown. Third, there was only one focus group per specialty, and participants were limited to expert surgeons; therefore, the diversity of views within each specialty and the perspectives of junior and mid-career surgeons may not have been fully captured. Future studies should include multiple groups per specialty and surgeons at different career stages. In addition, because all three groups were moderated by the same head and neck surgeon, existing professional relationships may have influenced both the participants' accounts and the moderator's probing in the head and neck group. However, a common structure was consistently observed in all three specialties, making it unlikely that this asymmetry substantially affected the main conclusions. Fourth, using countertraction as the starting point may have influenced the situations that participants recalled and the range of their accounts, although no definition of the term was provided and the analysis was not limited to statements containing the word. Finally, this study presented a conceptual framework but did not test whether its use in education, assessment, or feedback improves surgical performance or patient outcomes; thus, interventional studies are needed.

Conclusions

Among expert surgeons across the three specialties, tension management was organised as a WHY-HOW-WHAT cognitive–operative process linking principles, judgement, and execution. By making explicit the cognitive layers that underlie observable operative movements, the framework offers a shared process language for teaching tacitly practised skills and a conceptual basis for interpreting data-driven measures of operative performance. Both applications require validation against intraoperative data and educational outcomes.

List of abbreviations

GIS, gastrointestinal surgery; GYN, gynaecological oncology; HNS, head and neck surgery; OSATS, objective structured assessment of technical skill; SRQR, standards for reporting qualitative research.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Review Committee of Ehime University (registration number 2402007) and was conducted in accordance with the Declaration of Helsinki. All participants received an explanation of the study and provided written informed consent.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Funding

This study was supported by JSPS KAKENHI (grant numbers 24K00451 and 25K22844).

Author Contribution

SM: conceptualisation, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, writing – original draft, writing – review and editing. SP: formal analysis, investigation, methodology, project administration, writing – original draft, writing – review and editing. SA: conceptualisation, investigation, project administration, writing – review and editing. T Kim: formal analysis, methodology, writing – original draft, writing – review and editing. KK: formal analysis, investigation, methodology, project administration, writing – original draft, writing – review and editing. KS: investigation, project administration, writing – review and editing. YI: conceptualisation, investigation, writing – review and editing. YH: investigation, project administration, writing – review and editing. KT: investigation, project administration, writing – review and editing. T Kit: investigation, writing – review and editing. TM, HW, and NH: conceptualisation, supervision, writing – review and editing. All the authors have read and approved the final version of the manuscript.

Acknowledgement

The authors thank the surgeons at all participating institutions for their cooperation in this study. The authors also thank Masato Yoshihara, MD, PhD; Hideki Takami, MD, PhD (Nagoya University); and Toru Ugumori, MD, PhD (Ugumori ENT Clinic), for their assistance in recruiting surgeons and conducting the focus groups. None of the named individuals received compensation for their contribution to the study. English language editing was performed by Editage (Cactus Communications) and funded by JSPS KAKENHI grant 24K00451.

Data Availability

Because the focus group transcripts contain contextual details through which individual expert surgeons could be identified and because participant consent was limited to use by the research team, the underlying qualitative data are not publicly available. De-identified excerpts beyond those presented here may be available from the corresponding author upon reasonable request, subject to ethics committee approval.

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Figures

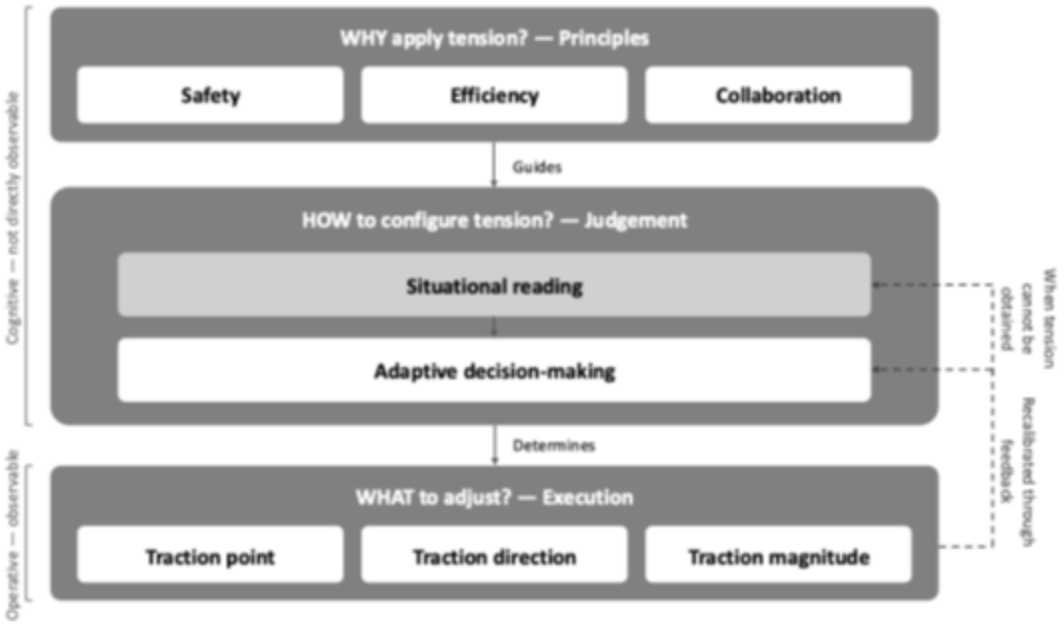


Figure 1

The WHY-HOW-WHAT framework of tissue tension management during surgical dissection.

Among the expert surgeons, tension management was organised as a three-layer cognitive–operative process. WHY (principles: safety, efficiency, and collaboration) guides HOW (judgement), which determines WHAT (execution: traction point, direction, and magnitude). Within the HOW layer, situational reading informs adaptive decision-making regarding the tension required at a given moment. The solid arrows indicate that each upper layer governs the layer below it. Dashed arrows indicate recalibration;

changes produced by execution are fed back first to adaptive decision-making, and, when appropriate tension cannot be obtained, to situational reading. The brackets separate the cognitive layers, which cannot be observed directly, from the operative layer, which can be observed and measured. Shading marks situational reading as the component in which the differences between specialties are primarily located.

Alt text: Diagram of three stacked grey bands labelled with WHY apply tension? (Principles: safety, efficiency, and collaboration); HOW to configure tension? (Judgement: situational reading above adaptive decision-making, with a grey arrow from the former to the latter); and WHAT to adjust? (Execution: traction point, direction, and magnitude). Solid arrows labelled Guides and Determines run downward between the bands. The dashed arrows return from the execution band to adaptive decision-making (recalibrated through feedback) and to situational reading (when tension cannot be obtained). The brackets on the left mark the upper two bands as cognitive and not directly observable, and the lower band as operative and observable.

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