

An atraumatic retractor for interdisciplinary use in conventional laparoscopy and robotic surgery

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Abstract

Background: The removal of obstacles from the surgical field is a crucial aspect of any procedure in gynecological, urological or visceral laparoscopic surgery. Reliable instruments and skilled assistance are essential for the smooth execution of procedures. Blunt forceps are commonly used to keep tissue away from the operating field. The range of existing instruments has been enhanced by the introduction of laparoscopic retractors. However, no laparoscopic retractor can be used without causing tissue damage.

Material and methods: We describe the ALKATOUT retractor, an innovative laparoscopic retractor designed for atraumatic assistance in any laparoscopic procedure including robotic surgery. The advantages of this laparoscopic instrument were evaluated in a single-center study.

Results: The retractor has been used successfully in a variety of gynecological procedures and tested in laparoscopic procedures on human body donors.

Conclusions: The results of a single-center questionnaire completed by 25 operating room staff (surgical nurses, residents, and specialists) confirm the advantages of the ALKATOUT retractor.

Introduction

A clear operating field is an essential prerequisite for successful endoscopic surgery. The absence of any visual obstruction secondary to the bladder, uterus, adnexa, or bowel enables the surgeon to work precisely and smoothly. Furthermore, a clear operating field permits accurate assessment of the use of electricity and thermal spread in a radical procedure. This is especially important when operating close to the bowel, ureter, major vessels, or nerves in the pelvis, the mid-abdomen, or the upper abdomen.⁵ A clear field of view is mandatory for all advanced endoscopic procedures based on conventional laparoscopy or robotic-assisted surgery in gynecology, urology, or visceral surgery. Reliable atraumatic procedures are especially important in robotic-assisted surgery because camera motion is inflexible and the camera is moved by the surgeon himself in this setting.^{3,4}

Usually the assistant surgeon uses blunt forceps or an endoscopic fan to ensure clear visibility of the surgical field. This approach may be associated with tissue damage due to uncontrolled grasping. Besides, fans are expensive disposable instruments. A variety of endoscopic retractors have been developed by bowel surgeons. All of these are costly, complex in terms of usage and cleaning, and impractical for daily use.^{7,10,15} The assistant surgeon is occupied with handling the retractor or keeping tissue away from the operating field, which signifies an unsettled

surgical setup. Both the assistant and the surgeon are unable to concentrate fully on their immediate surgical task.

We designed a reusable endoscopic retractor for all laparoscopic procedures, including robotic-assisted surgery. It is easy to use, reasonably priced, permits maximum flexibility, and is entirely atraumatic.

We describe the rationale to develop the retractor and the challenges which had to be overcome during its construction as well as laboratory and in vivo tests. We analyzed the results of a questionnaire concerning the use of the retractor, filled by 25 operating room staff members.

Material and methods

A variety of laparoscopic retractors are available at the present time. We initiated a MEDLINE and PubMed search (National Center for Biotechnology Information, US National Library of Medicine, Bethesda, MD, USA) using the keywords 'laparoscopy' and 'retractor'. We looked for all entries on laparoscopic retractors in the English and the German language.

Keeping tissue away from the operating field is no easy task for the surgeon; it requires the use of a suitable instrument. Following the application of several self-made retractors in the laboratory, the first prototype of the ALKATOUT retractor was manufactured by KARL STORZ SE & Co. KG (Tuttlingen, Germany) in diameters of 5 and 10 mm. Its length of 43 cm enables the surgeon to reach deep into the pelvis. The retractor consists of three components, each of which can be replaced independently in the event of damage (Figs. 1a–c, 2a–c, 3a,b). The tip is curved on both sides, with the convex surface facing the tissue. This permits maximum force distribution and minimizes force on retracted tissue. The scope of the apex is >180°, thus permitting tissue parts larger than the diameter of the tip to be held safely. The instrument becomes flatter towards the shaft, thus providing a wide overview and permitting a large quantity of tissue to be held by the retractor. The handle has circular grooves at regular intervals and a hollow digital indentation pointing upward.



Fig. 1 3D CAD model for finite element analysis of the tip of the ALKATOUT retractor. The lines illustrate the force transmission paths to the instrument (a) and those to the shaft (b). Panel (c) clearly shows the well-adapted design of the concave tip.

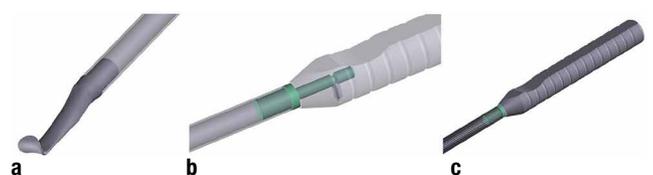


Fig. 2 The ALKATOUT retractor consists of three components. The proximal end of the tip component (a) is coupled to the shaft (b) which in turn is connected to the handle (c). Each component can be serviced or replaced independently in case of damage or wear.

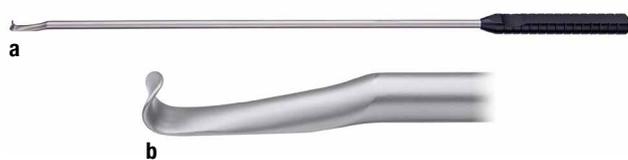


Fig. 3 Macroscopic view of the ALKATOUT retractor. Note the slender design of tip, shaft and handle. The straight handle is grooved for firm grip (a). Close-up view (b) showing the inward curved shape of the tip. The slender instrument facilitates handling and improves visualization of the surgical site. The inward curved tip design facilitates picking up large tissue fragments and evenly distributes the applied forces across its large surface, which is particularly useful during blunt exposure and mobilization maneuvers.

The retractor was tested in laparoscopy on human body donors at the institute of anatomy, University of Kiel, Germany (Figs. 4a,b, 5a,b). The cadavers were provided by donors who consented in writing to the use of their bodies for clinical purposes. The declarations were worded in accordance with German law.

More than 50 procedures were performed on the basis of conventional laparoscopy and robotic-assisted surgery. These included adnectomy, simple and radical hysterectomy, ureterolysis, sacropexy, pectopexy, lateral repair appendectomy, pelvic and paraaortic lymphadenectomy, and complete mobilization of the rectum.

The retractor was evaluated on the basis of the following criteria:

- It permits atraumatic handling of target tissue. Despite its rigid construction the retractor provides an unobstructed visual field and can be readjusted easily as per surgical requirements. The clear designation of its front, back, right and left aspect greatly facilitate its application.
- Position changes can be done swiftly and easily without putting at risk anatomical integrity.
- The retractor provides a stable and wide overview of the surgical field.
- The retractor is highly versatile in terms of structure and can be used interdisciplinarily in conventional laparoscopy and robotic surgery.
- The retractor is of considerable advantage in laparoscopic and robotic-assisted surgery.

The above items were included in a visual analog scale (VAS) questionnaire which the surgical team, consisting of five consultants, ten residents and ten surgical nurses, were asked to fill. When responding to a VAS item, the respondents specified their level of agreement by indicating a position along a continuous line between two endpoints ranging from 0% (strongly disagree) to 100% (strongly agree). The data obtained from the questionnaire were subjected to statistical analysis.

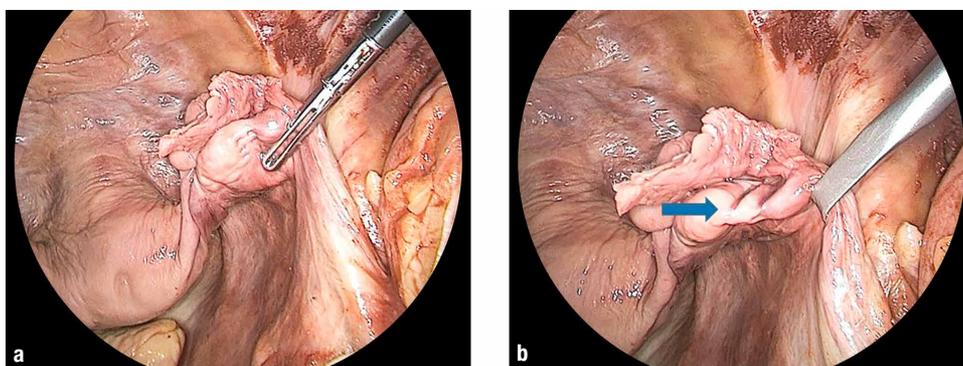


Fig. 4 Laparoscopic still images taken during a cadaver study. A blunt grasping instrument is used to mobilize the infundibulopelvic ligament (a). The arrow in panel (b) indicates the deep tissue mark which is left after the grasper has been released. The potential extent of tissue damage depends on the force applied through the handle and transmitted by the jaws of the grasper (a). In contrast, use of the retractor (b) permits smooth handling of tissue and to expose the area of interest without jeopardizing integrity of the infundibulopelvic ligament. The exerted force is distributed over the entire surface of the instrument tip.

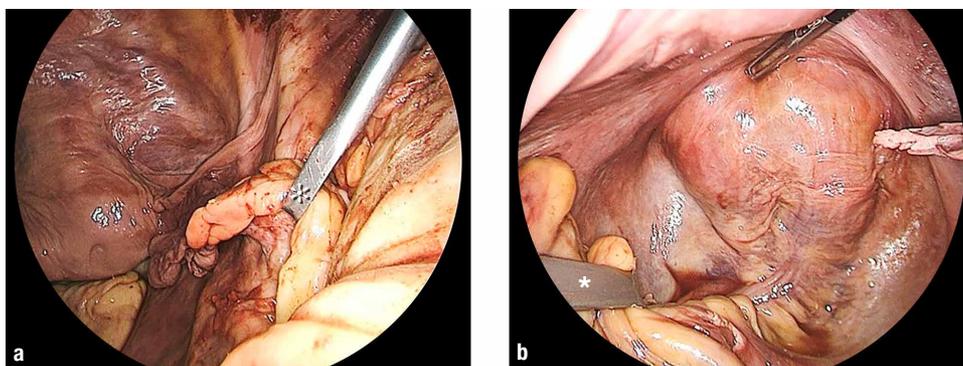


Fig. 5 Laparoscopic still images taken during a cadaver study. The 5-mm retractor (*) permits thicker parts of the bowel to be held away from the operative site (a), e.g., the vermiform appendix. Large bowel segments (b), such as sigmoid colon or rectum can be kept away from the surgical field with the 10-mm retractor (*).

Cadaver fixation

The donor's body is undressed, shaved, and cleaned. The cadaver is infused with 20 liters of the fixative EG-70 [(70% ethanol, 30% glycerin, 0.3% Lysoformin® (Lysoformin®: 100 g contain 6.0 g formaldehyde, 1.8 g glutaral, and sodium alkyl ether sulfate)] via the femoral artery. The artery is dissected and the fixative introduced through a blunt cannula into the cranial and caudal aspect; half a liter is administered for 30 min, followed by a 20-min break. This is repeated until 20 liters of EG-70 have been administered. The procedure takes about 48 h. The fixed cadaver is packed in cloths moistened with a solution of thymol (300 g of crystalline thymol in 100 liters of 10% ethanol) and stored at 4 °C. In addition to retaining the body's natural color, the consistency and transparency of tissue are similar to those achieved with other methods of embalming. Unlike other surgical laboratory setups such as a dry lab, a wet lab or an animal lab, surgery on body donors is the only means of working in an authentic anatomical setup.

Results

The database search revealed no reusable devices for the maintenance of a clear operating field in conventional laparoscopy or robotic-assisted surgery.

The retractor was developed in 2016 and used by Dr. Ibrahim Alkatout to perform laparoscopic procedures on human body donors (Figs. 4a,b; 5a,b). The topographic anatomy of the body was best maintained in cadavers treated by the glycerol-based fixation method. Several features of laparoscopic procedures on cadavers, such as the creation of a pneumoperitoneum, the use of electrosurgery (bipolar and monopolar) and realistic tissue dissection, are very similar to those in a living patient. This is a precondition for evaluating any new instrument. In other words, the retractor was tested in an authentic setting.

After registration and approval in 2017, the ALKATOUT retractor was successfully used in various conventional laparoscopic and robotic-assisted procedures in gynecology.

Ten surgical nurses (seven female and three male), ten residents (nine female and one male), and five specialists (two female and three male) completed the questionnaire (Figs. 6a–f). The age of the surgical nurses ranged between 20 and 60 years, that of the residents between 26 and 35 years, and that of the specialists between 39 and > 65 years. The results of the questionnaire are summarized in Table 1 and Fig. 7.

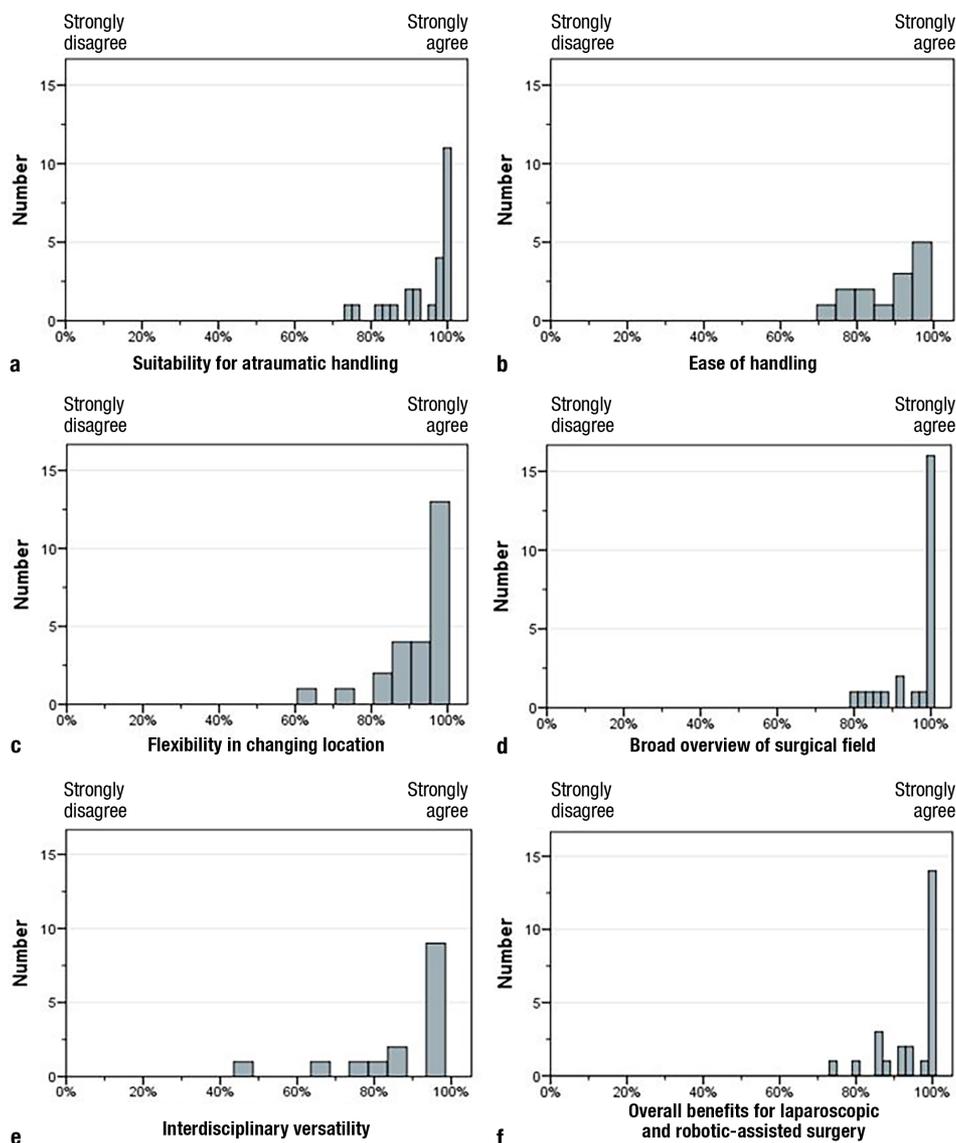


Fig. 6 Results of the questionnaire completed by surgical nurses, residents and specialists who worked with the ALKATOUT retractor.

The following descriptive criteria were evaluated:

- a.** The retractor permits atraumatic handling of target tissue.
- b.** Despite its rigid design, the retractor provides an unobstructed visual field and can be easily readjusted to meet the needs of the surgeon.
- c.** Any change in position can be done swiftly and easily without putting at risk anatomical integrity.
- d.** The retractor provides a stable and wide overview of the surgical field.
- e.** The retractor is highly versatile in terms of structure and can be used in interdisciplinary conventional laparoscopy and robotic surgery.
- f.** The retractor is of considerable advantage in the field of laparoscopic and robotic-assisted surgery.

The respondents specified their level of agreement by indicating a position along a continuous line (visual analog scale) between two endpoints ranging from 0% (strongly disagree) to 100% (strongly agree).

	Number	Mean	Standard deviation	Minimum	Maximum	Percentile		
						25	50 (Median)	75
Suitability for atraumatic handling	25	93.88	8.16	74.00	100.00	89.50	98.00	100.00
Ease of handling	25	94.04	8.40	72.00	100.00	89.00	98.00	100.00
Flexibility in changing location	25	92.28	9.46	63.00	100.00	87.50	96.00	100.00
Broad overview of surgical field	25	95.80	6.81	80.00	100.00	91.50	100.00	100.00
Interdisciplinary versatility	25	92.44	12.82	46.00	100.00	91.00	97.00	100.00
Overall benefit for laparoscopic and robotic-assisted surgery	25	94.60	7.48	74.00	100.00	90.00	100.00	100.00

Tab. 1 Descriptive statistics on the use of the ALKATOUT retractor.

Specialty	Field of application
Gynecology	Conventional laparoscopy and robotic-assisted laparoscopy
Urology	
Visceral surgery	

Tab. 2 Field of application of the ALKATOUT retractor.

The following three significant statements were made in the 'Free Comments' section of the questionnaire:

■ The ALKATOUT retractor can be used by beginners. No previous laparoscopic experience is necessary; the retractor poses no additional risk during surgery.

■ One disadvantage is that the retractor is not bowshaped; a bow-shaped instrument would possibly enhance and enlarge the surgical field.

■ Can the 5-mm instrument be considered blunt when retracting tissues of large diameters?

The retractor was very useful in patients with gynecological cancers, in urogynecology, and in deep infiltrating endometriosis. In general surgery it is used for a variety of indications, such as operations in the stomach, the small bowel, the colon, and the pancreas. In urology the retractor is used for operations in the prostate gland, the kidneys, the bladder, and for lymphatic drainage. In fact, the instrument can be used in any type of endoscopic surgery for keeping tissue and organs away from the field of operation (Table 2 and Figs. 5a,b).

Discussion

The ALKATOUT retractor is a surgical device for endoscopic procedures performed by gynecologists, urologists, and visceral surgeons. It permits gentle manipulation and protection of tissue in the operating field. In the future it is expected to minimize surgical manipulation with forceps, improve visualization of the operating field, and reduce operating times. Owing to its easy handling, the retractor can be used effectively while there is no need to pay undue attention to the instrument itself. Instead, this allows the surgeon to remain focused on the surgical task at hand. Furthermore, the atraumatic retractor keeps adjacent organs beyond the reach of lateral thermal spread, thus causing fewer complications due to direct or indirect tissue damage.^{2,14}

The database search revealed original articles on wound auto-retractors for laparotomy,^{6,13} minimally invasive liver retractors,^{8,9} and a snake retractor for single-incision cholecystectomy.¹⁶ In a preliminary analysis O'Shea *et al.* tested an atraumatic inflatable laparoscopic retractor for retracting the bowel during colectomy.¹²

In one report the authors described their initial experience with a single-use laparoscopic dynamic retractor. Although the instrument could be used safely and easily, it was designed for disposable use and involved a complex setup.¹⁵ Another investigation addressed a retracting anchoring system which can be

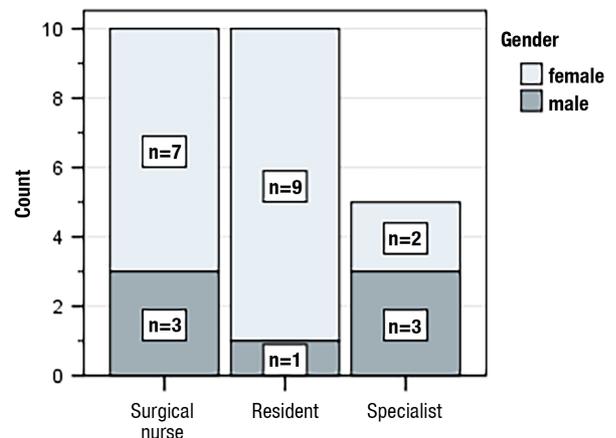


Fig. 7 Sociodemographic data of the study group.

anchored internally and fixes the target organ to the abdominal wall. Although the device can be adjusted repeatedly, its application is time-consuming. Besides, it is a single-use instrument and seems to be less flexible in use than other retraction devices. In our experience complete exposure is required – similar to that in open surgery – before it can be used on specific target tissue.¹⁰ No retraction device offers the advantages of the ALKATOUT retractor.^{1,17} Any retractor is expected to facilitate retraction, provide an unobstructed and wide overview of the surgical field, and eventually economize on operating room staff while minimizing patient morbidity.

Advanced laparoscopic procedures require a clear surgical field. The presence of pathologies, especially in patients with a history of previous surgery, extended adhesions or deep infiltrating endometriosis can obscure the view of the surgical site.¹¹ The surgeon must be able to fully concentrate on the surgical procedure. Frequent changes of instruments or the need to grasp tissue repeatedly can prompt the surgeon to orient away from a primary task which can disrupt control over the surgical procedure.¹⁸

Once the ALKATOUT retractor has been tested in various surgical settings and accepted by gynecological, surgical and urological societies, it may well be incorporated in the repertoire of basic laparoscopic instruments.

Acknowledgements

The author thanks Dr. h.c. mult. Sybill Storz from KARL STORZ SE & Co. KG (Tuttlingen, Germany) for supporting the development of the ALKATOUT retractor, Dawn Ruether for editing the manuscript, and Ulrike von Hehn (medi-stat.de) for her assistance in statistical analysis.

Declaration of interest

The author declares that there is no conflict of interest and no source of funding.

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Original article:

Alkatout I. An atraumatic retractor for interdisciplinary use in conventional laparoscopy and robotic surgery. *Minim Invasive Ther Allied Technol* 2018;27(5):265–71. doi:10.1080/13645706.2018.1440244.

<https://doi.org/10.1080/13645706.2018.1440244>

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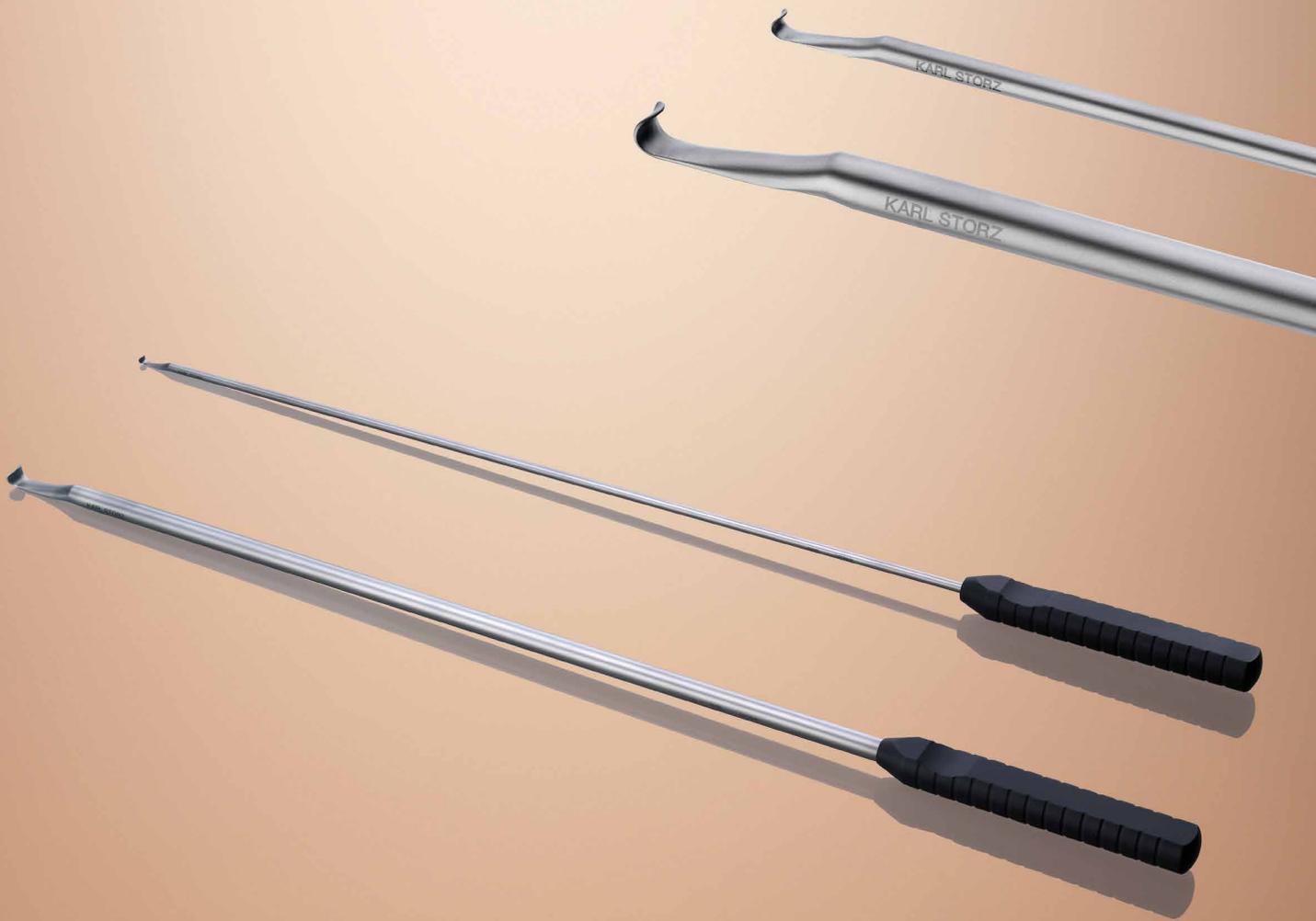
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ALKATOUT Retractor

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- Gentle retraction of tissue for better visualization of the procedure site
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