European Journal of Plastic Surgery (2019) 42:49–54
https://doi.org/10.1007/s00238-018-1450-z

ORIGINAL PAPER

Proximal carpal crease incision for carpal tunnel release: a pilot study

Rytis Rimdeika[1,2] · Adas Cepas[1,2] · Rokas Liubauskas[2] · Loreta Pilipaityte[1,2] · Inesa Rimdeikiene[3]

Received: 27 May 2018 / Accepted: 6 August 2018 / Published online: 19 August 2018
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Abstract

Background Limited palmar incision (PI) is the standard approach for treatment of carpal tunnel syndrome. Proximal carpal crease incision (CI) is an investigated alternative. The aim of our study was to evaluate safety and results of PI and CI approaches.

Methods A prospective, randomised, open label pilot study was carried out in the period of November 2011–November 2017. A total of 104 patients were randomised into two groups according to the incision: group 1 (CI) had 33 patients and group 2 (PI) had 71 patients. Measured characteristics are the following: safety, severity of pain, DASH score, hand grip and pinch strength, two-point discrimination test and Semmes-Weinstein monofilament test. Data were collected 1 h before surgery, in the early (2–3 weeks after surgery) and late (3–4 months after surgery) post-operative periods. A significance level of 0.05 was considered for testing statistical hypotheses.

Results We found that CI results in lower early ($p = 0.064$) and late ($p = 0.033$) post-operative period pain and better hand function: lower DASH score in early ($p = 0.005$) and late ($p = 0.047$) post-operative period and stronger hand pinch in early post-operative period ($p = 0.037$). However, hand grip strength, two-point discrimination and Semmes-Weinstein monofilament test did not reveal any significant differences between the study groups. No major complications appeared in both study groups; thus, both incisions were considered safe.

Conclusions Pilot study suggests that CI is a safe alternative treatment method of the carpal tunnel syndrome resulting in faster patient recovery after carpal tunnel release.

Level of Evidence: Level I, therapeutic study.

Keywords Carpal tunnel · Carpal tunnel release · Median nerve · Retinaculotomy · CI · PI

Introduction

Carpal tunnel syndrome (CTS) is a compressive mononeuropathy of the median nerve as it crosses the wrist with nine flexor tendons through the carpal tunnel (CT), which is formed by the transverse carpal ligament anteriorly and carpal bones posteriorly. CTS is the most common peripheral nerve mononeuropathy seen in medical practice worldwide, with incidence ranging from 324 to 542 for women and 125 to 303 for men per 100,000 population annually [1, 2]. CTS often occurs in middle-aged women with a female to male ratio of 2.07 [3].

Numbers of risk factors have been associated with CTS including diabetes, obesity, pregnancy, hypothyroidism, genetic predisposition, workplace factors and some drugs. However, the aetiology of increased CT pressure is still uncertain. There are two possible mechanisms of median nerve entrapment—inflammation and/or anatomical compression. The inflammatory mechanism causing tenosynovitis and reducing the space in the CT occurs due to workplace factors, hormonal changes or systematic illnesses such as rheumatoid arthritis. Anatomical compression usually occurs as a result of subsynovial connective tissue fibrosis that surrounds the flexor tendons or due to congenitally small anatomic space in the CT [4]. Another example of anatomical compression could be space-occupying lesions such as cysts or neoplasms [5]. Increased pressure in

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s00238-018-1450-z) contains supplementary material, which is available to authorized users.

✉ Adas Cepas
adascepas@yahoo.com

[1] Plastic and Reconstructive Surgery Department, Hospital of Lithuanian University of Health Sciences Kauno Klinikos, Eivenių Str. 2, LT 50009 Kaunas, Lithuania

[2] Medical Faculty, Lithuanian University of Health Sciences, A. Mickevičiaus Str. 9, LT 44307 Kaunas, Lithuania

[3] Department of Rehabilitation, Hospital of Lithuanian University of Health Sciences Kauno Klinikos, Eivenių Str. 2, LT 50009 Kaunas, Lithuania

the CT can injure the nerve directly, impair axonal transmission or vessel compression in the perineurium and cause median nerve ischaemia [6].

The most common symptoms of CTS include pain, paraesthesia, numbness with involvement of the first three and a half digits supplied by the median nerve. Symptoms may progress to weakness and atrophy of the thenar muscles, along with sensory loss in the affected fingers [2, 3]. Diagnosis of CTS mainly relies on clinical symptoms and nerve conduction tests.

The treatment of CTS consists of non-surgical treatment and surgical release. Surgical decompression is the treatment of choice for patients undergoing conservative treatment without any improvement or the ones who have severe median nerve injury, characterised by significant axonal degeneration and demyelination on nerve conduction studies [7–12]. There are two main surgical techniques for carpal tunnel release—open and endoscopic (ER). Open CT release can be performed through a standard 4–6-cm palmar incision (SPI) and limited palmar incision (PI) of less than 2 cm in length. PI is regarded as the gold standard because of advantages in short-term post-operative results, including faster patient recovery, reduction in pillar pain and cost-effectiveness [13–15]. Endoscopic CT release can be performed using one or two portal techniques, both of which show better short-term post-operative results without significant advantages in long-term results compared to open techniques [16–19]. However, ER requires proper training and is way more expensive compared to open CT release [14, 20, 21].

In this article, we present our experience while investigating an alternative approach for CT release—proximal carpal crease incision (CI) with special emphasis on the technical points including the location of the skin incision, safety, instruments and comparison with PI technique.

Patients and methods

A prospective, randomised, open label pilot study was carried out from November 2011 to November 2017. A total of 104 patients with clinically and electrophysiologically diagnosed CTS were included in the study. Patients were randomised into two groups according to the incision: group 1 (CI) had 33 patients and group 2 (PI) had 71 patients. The study was approved by the Ethics Committee of both Kaunas Regional Biomedical Research and Lithuanian University of Health Sciences Hospital Kauno Klinikos. Data were collected from patient clinical records using standard questionnaires and included age, gender, medical comorbidities, social status, and results of nerve conduction studies (electromyography). Pain (visual analogue scale, VAS) and physical examination measurements, i.e. hand grip and pinch strength, two-point discrimination test, Semmes-Weinstein monofilament test, and the disabilities of the arm, shoulder, and hand (DASH) questionnaire, were evaluated on the operation day and followed-up in the early post-operative period (2–3 weeks after surgery) and the late post-operative period (3–4 months after surgery). A dynamometer was used to evaluate hand grip strength; pinch strength was evaluated with a pinch gauge. The presence or absence of thenar atrophy and Tinel's and Phalen's signs were identified, pre-operatively. Data were analysed using SPSS (Statistical Package for Social Sciences) software version 24.0. An independent-samples Student's t test was used to compare the parametric variables between two groups, and the chi-square test was also used. Mean data are represented as the mean ± standard deviation. P values less than 0.05 were considered significant.

Skin incision

Immediately before this study, we used the distal carpal crease incision due to its close proximity to the transverse carpal ligament. However, we observed high rates of surgical site inflammation, delayed wound healing and the presence of scar hypertrophy with this technique. The signs of inflammation remained for a longer period of time than was expected for fluent post-operative recovery (Fig. 1). Since the distal carpal crease is the pivot point of wrist movement, it is prone to the repeated trauma of daily life. As a result, we decided to exclude distal carpal crease incision cases from the study and change the location of the incision to the proximal carpal crease. We observed that proximally located incisions healed faster, and scars were more cosmetically acceptable and less problematic for the patient. All surgical wounds healed under primary intention without any delays or complications.

Carpal tunnel release with limited palmar incision approach

The surgery started with a median nerve block 2 cm proximal to the planned incision site. A standard solution of 2% lidocaine was used. The skin and subcutaneous tissue of the planned incision site and the projection of the carpal ligament were infiltrated,

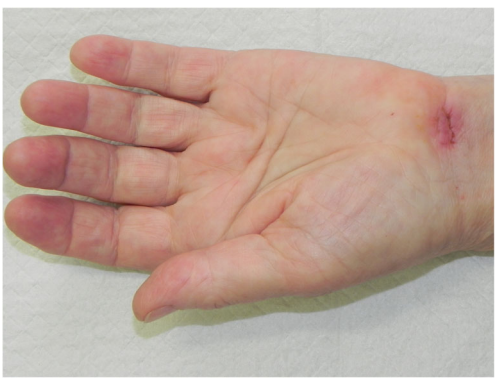

Fig. 1 Fourteen days after the surgery. Excessive surgical site inflammation and delayed wound healing observed

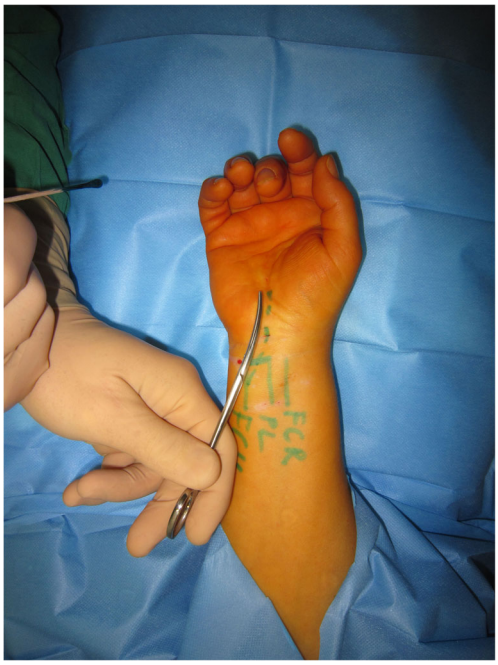

Fig. 2 The positioning of surgical scissors. The site of incision and surrounding tendons marked pre-operatively. FCR flexor carpi radialis, PL palmaris longus, FCU flexor carpi ulnaris

according to local anaesthesia technique, with 2% lidocaine and 1:100,000 epinephrine mix. The operated arm was exsanguinated and pneumatic tourniquet was used. 1.5–2 cm longitudinal palmar incision was made proximal to the Kaplan's cardinal line in the axis of the radial side of the fourth finger. Careful dissection was performed. The carpal ligament was identified by direct viewing. Transverse carpal ligament was transected starting from the distal pole. Metal spacer (tentacannula) was used in order to avoid median nerve injury and continue transverse carpal ligament and anterior forearm fascia division proximally. The carpal

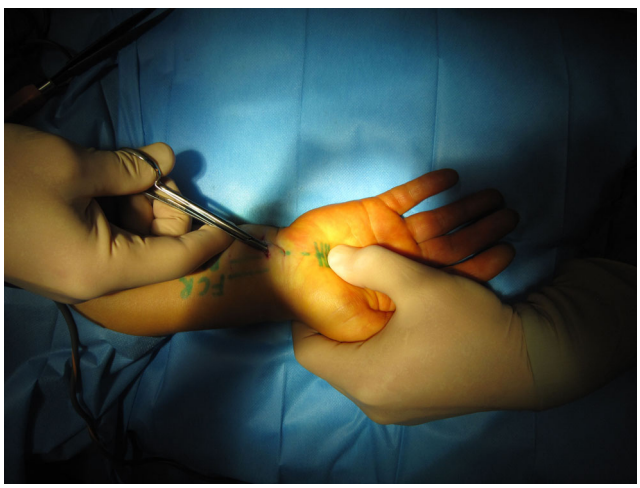

Fig. 3 Carpal ligament being transected with scissors from proximal to distal end. Kaplan's cardinal line permanently controlled and protected by firmly holding the thumb of the opposite hand of the operating surgeon

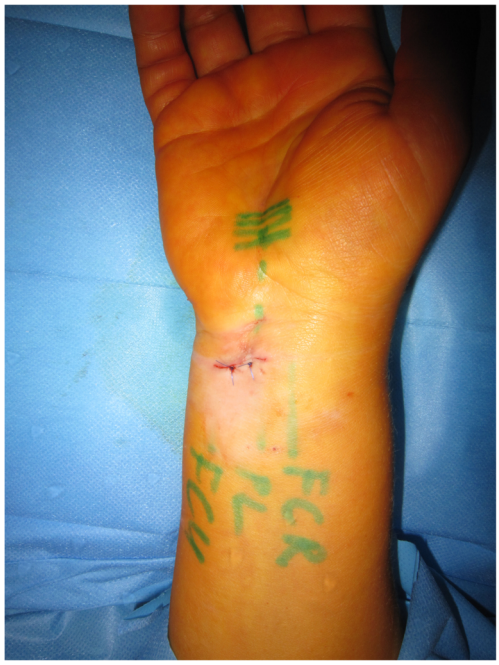

Fig. 4 Wound closure with single stitches

ligament and distal part of the anterior forearm fascia were sectioned completely. After adequate haemostasis was obtained, the skin was closed with single stitches of 4-0 polypropylene non-absorbable sutures. A sterile wound dressing with compressive cotton gauze on top was applied with a non-elastic bandage. The wrist was not splinted.

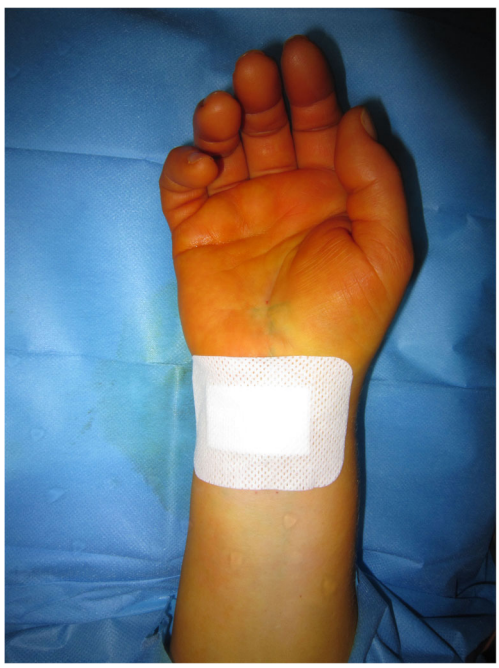

Fig. 5 Sterile wound dressing applied on surgical wound. Additional compressive cotton gauze was applied on top with a non-elastic bandage (not shown)

Table 1 Demographics of the study population

Patient demographics	CI ($n = 33$)	PI ($n = 71$)	p value
Age, years (mean ± SD)	59.06 ± 10.95	56.51 ± 11.94	0.321
Gender, female/male ratio	24/9	56/15	0.126
Time between 1st and 2nd follow-up (days)	21.73 ± 5.14	21.84 ± 7.25	0.933
Time between 1st and 3rd follow-up (days)	89.48 ± 31.04	98.32 ± 31.3	0.182

Carpal tunnel release with proximal carpal crease approach

The procedure started with a standard median nerve block, 2 cm proximal to the planned incision. A standard solution of 2% lidocaine was used for this procedure. The skin and subcutaneous tissue of the planned incision site and the projection of the carpal ligament were infiltrated, according to local anaesthesia technique, with 2% lidocaine and 1:100,000 epinephrine mix. No tourniquet was used. A 15–20-mm transverse incision was made from the ulnar proximal carpal crease to the palmaris longus tendon to expose the anterior forearm fascia (Fig. 2). The fascia was bluntly dissected in line with the skin incision and incised by scalpel, proximally and distally, 5–7 mm perpendicular to it. Curved surgical scissors with a blunt tip was placed into the CT and directed in line with the radial side of the fourth finger. The anterior forearm fascia and carpal ligament were cut with scissors from proximal to distal end not exceeding Kaplan's cardinal line. Kaplan's cardinal line was permanently controlled and protected by firmly holding the thumb of opposite hand of the operating surgeon (Fig. 3). After adequate haemostasis was obtained, the skin was closed with single stitches of 4-0 polypropylene non-absorbable sutures (Fig. 4). A sterile wound dressing with compressive cotton gauze on top was applied with a non-elastic bandage (Fig. 5). The wrist was not splinted.

Results

According to the patients' age, the time between early post-operative and late post-operative evaluations in both study groups were homogenous (Table 1). Pre-operative pain (VAS) did not differ significantly ($p = 0.666$), while early post-operative pain reduction showed promising results for the CI group ($p = 0.064$). Additionally, late post-operative pain reduction was an advantage of the CI technique ($p = 0.033$) (Table 2). Hand grip strength did not differ significantly between study groups neither in the pre-operative nor post-operative periods (Fig. 6). However, early post-operative hand pinch strength was greater in the CI group ($p = 0.037$). Although, late post-operative period did not indicate significant difference between study groups (Table 3). The results of the DASH questionnaire affirmed the advantage of the CI method over PI method in both post-operative stages (Fig. 7). Semmes-Weinstein monofilament test (SWT) and two-point discrimination test results (TPDT) did not differ significantly between study groups in both the pre-operative (SWT, $p = 0.758$; TPDT, $p = 0.171$) and post-operative periods (SWT $p = 0.549$ and $p = 0.624$; TPDT $p = 0.502$ and $p = 0.341$) (Table 4). There were no major complications related to nerve or superficial palmar arch injury encountered in any of the study groups neither wound infections were observed. However, subacute haematoma formation was noticed 2–5 days post-operatively in three patients (two in PI group and one in CI group) following re-initiation of indirect acting anticoagulants in outpatient care. Excessive scarring was observed in two patients of PI group.

Table 2 Pain assessment results with VAS during pre-operative and post-operative follow-ups

Examination time	PI ($n = 71$)	CI ($n = 33$)	p value
Pre-operative examination (1st) Mean ± SD[b]	5.48 ± 0.28	5.70 ± 0.42	0.666
Post-operative examination (2nd) Mean ± SD	2.68 ± 0.27	1.79 ± 0.39	0.064
Post-operative examination (3rd) Mean ± SD	1.21 ± 0.21	0.39 ± 0.31	0.033

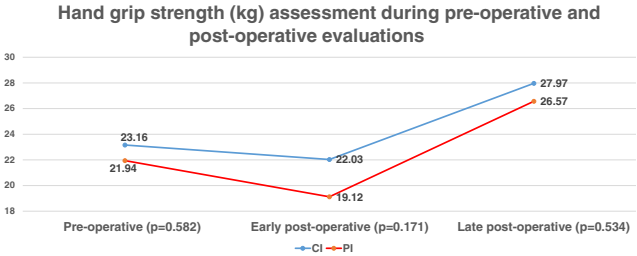

Fig. 6 Hand grip strength comparison between study groups

Discussion

Skin problems are one of the drawbacks of PI for CT release, since the longitudinal incision is made on the pillar aspect of the hand (which is prone to repeated trauma in daily life). Proximally located skin incisions reduce skin tension, thus reducing scarring complications and early post-operative pain [22]. This prospective pilot study was undertaken to compare early and late post-operative results of PI and the alternative surgical approach for CT release—CI. CI is also used in uniportal endoscopic CT release surgeries. The uniportal endoscopic technique is known for faster patient recovery, lower pain levels in the early post-operative period and better hand grip and pinch strength compared to PI [16]. According to our study, the CI method resulted in a lower tendency toward pain in the early post-operative period and showed superiority in late post-operative pain reduction. However, hand grip strength did

Table 3 Hand pinch strength comparison between study groups

Examination time	PI ($n = 68$)	CI ($n = 33$)	p value
Pre-operative examination (1st) Mean ± SD	5.14 ± 2.19	5.68 ± 2.63	0.323
Post-operative examination (2nd) Mean ± SD	5.14 ± 2.38	6.19 ± 2.15	0.037
Post-operative examination (3rd) Mean ± SD	6.98 ± 2.43	7.25 ± 2.14	0.524

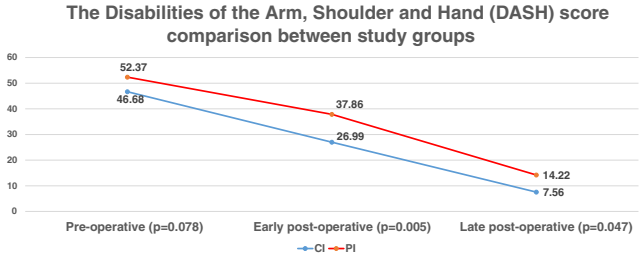

Fig. 7 The disabilities of the arm, shoulder and hand (DASH) score comparison between study groups

not differ between study groups significantly. Faster hand pinch strength recovery in the early post-operative period was also observed in the CI group. Moreover, DASH score results indicated faster patient recovery after CT release using the CI method. Yoo et al. in their pilot study used a similar technique (transection through the distal wrist crease) for CT release and reported faster patient recovery after the surgery [22]. However, Nazerani et al. noticed in their study that retinaculotomy through distal wrist crease incision results in compromised wound healing and long-lasting inflammation at the surgical site [23]. Before the study, we used a distal wrist crease incision, which we rejected on the same grounds.

Alves in their prospective study used similar approach to our CI for the carpal tunnel release and reported one case of incomplete carpal ligament transection. In this case, the patient underwent second decompression of the median nerve using standard palmar incision method. However, Alves reported less "pillar" pain 3 months post-operatively in the carpal incision group [24]. In our study, the tendency of lower pain level was noticed even 2 weeks after the surgery; 3 months post-operatively, the difference was statistically significant and showed CI method superiority.

During our research, there were no clinical signs of incomplete carpal ligament transection observed during early and late post-operative follow-ups in any study groups. No major complications associated with median nerve injury, superficial palmar arch injury or wound healing were observed in the study groups.

The visual demonstration of the CI technique with anatomical landmarks and median nerve branching (according to Lanz [25]) is provided in Fig. 8. We observed that even with atypical courses of the median nerve, the procedure is safe if the positioning of the curved surgical scissors is in the proper axis and not exceeding Kaplan's cardinal line, which has to be controlled during the transection of the carpal ligament since the superficial palmar arch is approximately 10 mm from its distal part.

In comparison to the uniportal endoscopic technique, the CI method is way more socioeconomically efficient since the endoscopic technique requires proper training and special optical devices and blades used for carpal ligament transection are disposable, making this technique way more expensive compared to open methods [14].

Table 4 Results of two-point discrimination (TPDT) and Semmes-Weinstein monofilament (SWT) tests between study groups in pre-operative and post-operative periods

Variable	Evaluation time	PI ($n = 71$)		CI ($n = 33$)	p value	
Two-point discrimination test, mm (mean ± SD)	Pre-op	6.56 ± 4.96		5.27 ± 2.79	0.171	
	Early post-op[c]	4.91 ± 4.44		4.44 ± 4.10	0.502	
	Late post-op[d]	5.08 ± 4.03		4.03 ± 3.74	0.341	
Study group	Evaluation time	Semmes-Weinstein monofilament diameter				
		2.83	3.61	4.31	4.56	6.65
CI ($n = 33$)	Pre-op, (n) %	3 (9.1%)	11 (33.3%)	10 (30.3%)	8 (24.2%)	1 (3%)
	Early post-op, (n) %	8 (24.2%)	18 (54.5%)	5 (15.2%)	1 (3%)	–
	Late post-op, (n) %	11 (33.3%)	16 (48.5%)	6 (18.2%)	–	–
PI ($n = 71$)	Pre-op, (n) %	7 (9.9%)	15 (21.1%)	25 (35.2%)	22 (31%)	2 (2.8%)
	Early post-op, (n) %	16 (22.5%)	34 (47.9%)	16 (22.5%)	3 (4.2%)	2 (2.8%)
	Late post-op, (n) %	28 (39.4%)	28 (39.4%)	11 (15.5%)	3 (4.2%)	1 (1.4%)

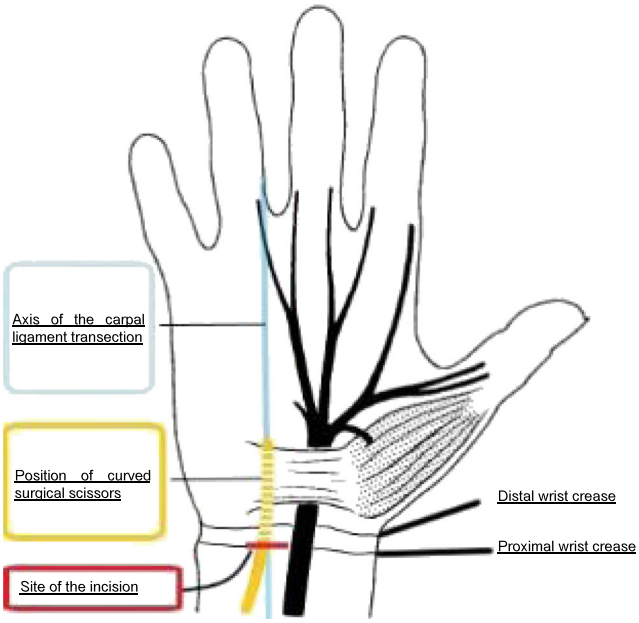

Fig. 8 Anatomical justification of the procedure (typical course and branching of the median nerve). Reproduced according to Lanz [23]

Conclusion

On the basis of our study, our investigated alternative approach (CI) is a safe surgical treatment method, which results in faster patient recovery after CT release and possesses benefits of both open and endoscopic methods.

Compliance with ethical standards

Conflict of interest Rytis Rimdeika, Adas Cepas, Rokas Liubauskas, Inesa Rimdeikiene and Loreta Pilipaityte declare that they have no conflict of interest.

Ethical approval All procedures involving human participants were performed in accordance with the ethical standards of the Ethics Committee of Kaunas Regional Biomedical Research and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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