

Anatomical Safety of the Open Approach in Carpal Tunnel Release: Critical Review of the Evidence and Analysis of the Role of the Tanzer Incision

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ABSTRACT

Introduction. Surgical carpal tunnel release constitutes the definitive treatment for patients with moderate to severe carpal tunnel syndrome (CTS). Although endoscopic techniques have gained popularity, open surgery continues to be widely performed, with comparable long-term functional outcomes. In this context, optimization of the skin incision and reduction of the risk of injury to the recurrent motor branch of the median nerve are of particular importance. The distal anatomical variability described by the Lanz classification provides a fundamental framework for safe surgical planning.

Objective. To critically analyze the available anatomical and clinical evidence regarding open carpal tunnel release, integrating the Lanz classification as the anatomical foundation, and to evaluate the role of the Tanzer incision as a potentially neurologically oriented safety approach. An illustrative clinical case is also presented.

Materials and Methods. A literature search was conducted in PubMed, Scopus, and the Cochrane Library between 1998 and 2024 using the terms “carpal tunnel release,” “Tanzer incision,” “median nerve variations,” “Lanz classification,” “recurrent motor branch,” and “safe zone.” Anatomical studies, clinical trials, meta-analyses, and systematic reviews published in English and Spanish were included. Particular emphasis was placed on distal median nerve variability patterns and their surgical implications. The review was complemented by the description of a clinical case treated using the Tanzer incision.

Results. The available comparative evidence does not demonstrate sustained long-term functional superiority of the endoscopic technique over the open approach, although it may be associated with faster recovery in the early postoperative period. The Lanz classification shows that most potentially vulnerable anatomical variants are located in the radial sector of the carpal tunnel, particularly transligamentous patterns and high divisions of the median nerve. Ulnar displacement of the approach, as proposed by the Tanzer incision, is based on the concept of an “anatomical lower-risk zone,” distancing the ligament division plane from the region where critical variants are concentrated.

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Conclusions. Safety in open carpal tunnel release largely depends on detailed knowledge of distal median nerve anatomical variability. The Lanz classification provides a useful conceptual framework for surgical planning. In the absence of demonstrated long-term clinical superiority of the endoscopic technique, anatomical optimization of the open approach is essential. The Tanzer incision may be considered an anatomically reasoned alternative aimed at neurological preservation; however, specific comparative studies are required to establish definitive recommendations.

KEYWORDS: Carpal tunnel release; Tanzer incision; Lanz classification; Recurrent motor branch; Median nerve variation

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INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common compressive neuropathy of the upper limb, with an estimated prevalence ranging from 3% to 5% in the general adult population and a higher incidence among middle-aged women (Atroshi et al., 1999; Chammas et al., 2014). Its pathophysiology is associated with increased intracarpal pressure and chronic compression of the median nerve beneath the transverse carpal ligament, leading to progressive demyelinating changes and, in advanced stages, irreversible axonal damage (Gelberman et al., 1981; Rempel et al., 1998).

Surgical treatment through division of the transverse carpal ligament is indicated in patients with persistent symptoms, motor deficit, severe electrodiagnostic abnormalities, or failure of conservative management (Keith et al., 2009; AANEM, 2011). Although the procedure is generally considered safe and highly effective, the literature reports complication rates ranging from 3% to 12%, many of which are directly related to the localization and orientation of the skin incision (MacDonald et al., 2003; Hobby et al., 2005).

The most feared complications include iatrogenic injury to the median nerve, its recurrent motor branch, the superficial palmar arch, and the palmar cutaneous branches, as well as the development of painful scars and persistent palmar dysesthesia (Taleisnik, 1992; Lanz, 1977). Multiple anatomical studies have demonstrated marked variability in the course of the recurrent motor branch of the median nerve, particularly in its radial emergence, thereby increasing the risk of injury when centrally placed or radially deviated incisions are used (Lanz, 1977; Henry et al., 2015).

In this context, the use of reliable anatomical landmarks, such as Kaplan's lines, has been widely recommended to delineate safe zones for incision and avoid critical neurovascular structures (Kaplan, 1953; Spinner & Kaplan, 1970). The Tanzer incision, described as a short longitudinal palmar incision positioned ulnar to the axis of the ring finger, has been proposed as a safe and reproducible alternative, as it remains distant from the usual course of the recurrent motor branch of the median nerve and the superficial palmar arch (Tanzer, 1959; Cobb et al., 1996).

The objective of this review is to analyze the evidence available over the past 25 years regarding the safest incision for surgical release of CTS, with particular emphasis on the Tanzer incision and strict adherence to Kaplan's lines, integrating the available anatomical, clinical, and surgical evidence.

CASE PRESENTATION

A 45-year-old female patient with a three-year history of progressive bilateral carpal tunnel syndrome presented for evaluation.

Clinically, she reported chronic paresthesias in the median nerve distribution (thumb, index finger, middle finger, and radial half of the ring finger), predominantly nocturnal, associated with burning pain, numbness, and progressive reduction in pinch and grip strength. She also described manual clumsiness, difficulty performing fine motor tasks, and frequent nocturnal awakenings, with partial symptom relief upon shaking her hands.

I. Physical examination: revealed positive Tinel and Phalen signs bilaterally, hypoesthesia within the median nerve territory, and weakness of the abductor pollicis brevis muscle, with clinical suspicion of incipient thenar atrophy.

Electromyography demonstrated bilateral compressive neuropathy of the median nerve at the level of the carpal tunnel, with chronic demyelinating changes and axonal involvement, consistent with the prolonged clinical course. Open surgical carpal tunnel release was therefore indicated.

II. Surgical Technique: Tanzer incision respecting Kaplan's lines.

The Tanzer incision consists of a short longitudinal palmar incision positioned ulnar to the axis of the ring finger. It begins distal to the wrist flexion crease and extends proximally into the palm without crossing the distal palmar crease. Strict adherence to Kaplan's lines is essential to prevent neurovascular injury:

- The superficial Kaplan line delineates the projection of the superficial palmar arch.
- The incision is maintained proximal and ulnar to this landmark.

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•The axis of the third digit is avoided, as this area represents a higher-risk zone for the recurrent motor branch of the median nerve.

Following skin incision and meticulous layer-by-layer dissection, the transverse carpal ligament is identified and divided under direct visualization, with careful protection of the median nerve and its branches. This approach provides adequate exposure, minimizes tissue trauma, and contributes to a reduction in procedure-related complications (*Figures 1-4*).



Figure 1. Preoperative image with markings including modified Tanzer incision.



Figure 2. Intraoperative image showing thickening of the carpal tunnel roof



Figure 3. Intraoperative image with the median nerve completely dissected



Figure 4. Postoperative image with closure using 3-0 nylon U-stitches

DISCUSSION

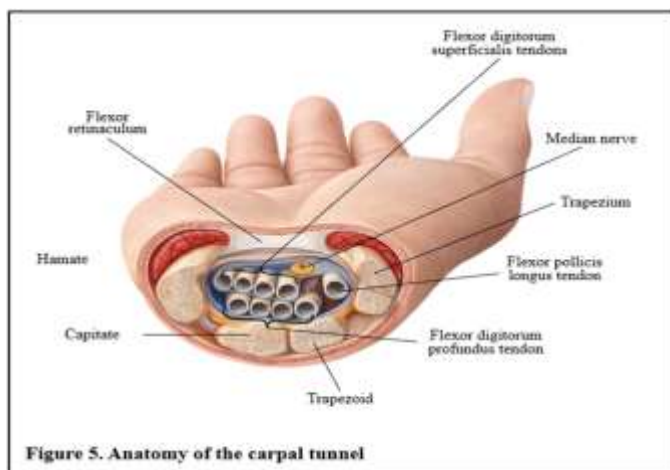
Carpal tunnel syndrome was first described in 1854 by the British surgeon James Paget, who documented the relationship between median nerve compression at the wrist

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and the development of sensory disturbances in the hand following distal radius trauma. His observations constituted the first recognition of a peripheral entrapment neuropathy, identifying that the symptoms originated not in the central nervous system but at a specific anatomical site of compression. During the twentieth century, the condition was further characterized clinically and electrophysiologically, eventually becoming established as the most common compressive neuropathy of the upper extremity.

Median nerve compression at the level of the carpal tunnel represents an entrapment neuropathy produced by sustained elevation of intracanalicular pressure within an inextensible osteofibrous space bounded by the carpal bones and the flexor retinaculum. The pathophysiological cascade begins with intraneural venous congestion and endoneurial edema, leading to microvascular ischemia. Progressive segmental demyelination ensues and, in advanced stages, secondary axonal degeneration develops, explaining the clinical transition from intermittent nocturnal paresthesias to permanent sensorimotor deficit. The etiology is multifactorial and includes repetitive mechanical factors (wrist flexion–extension movements, vibration exposure, manual loading), inflammatory and tenosynovial conditions (flexor tenosynovitis, rheumatoid arthritis), endocrine and metabolic disorders (diabetes mellitus, hypothyroidism, pregnancy), anatomical variations (accessory muscles, persistent median artery), and conditions that either reduce canal volume or increase its contents.

Diagnosis is primarily clinical and electrophysiological. It is suspected in the presence of pain and paresthesias within the median nerve sensory territory, weakness of the thenar musculature, and positive provocative maneuvers (Tinel, Phalen, carpal compression test). Confirmation is obtained through nerve conduction studies demonstrating prolonged distal sensory and motor latency with reduced conduction velocity. High-resolution ultrasonography and magnetic resonance imaging serve as complementary modalities, revealing increased cross-sectional area of the median nerve and structural alterations of the carpal tunnel. (Figure 5).

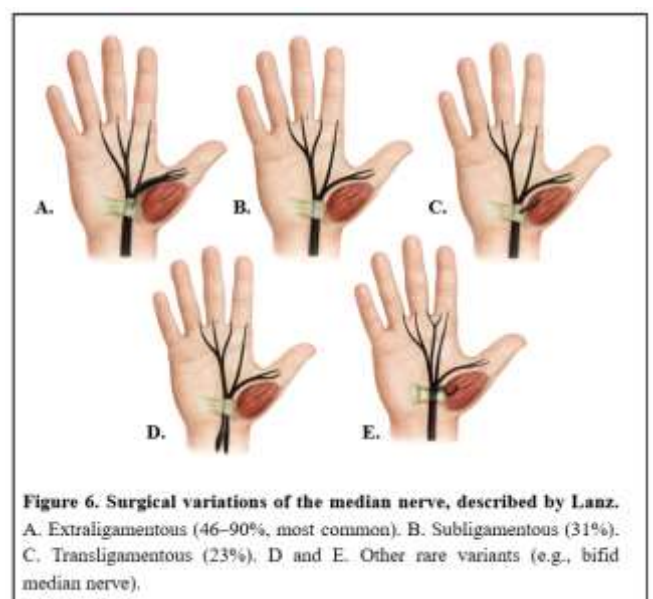


Surgical carpal tunnel release remains the definitive treatment for moderate and severe cases of CTS. Despite the development of endoscopic techniques and mini-open approaches, open surgery maintains significant relevance, supported by high-level comparative evidence that does not demonstrate clinically meaningful differences in long-term functional outcomes between the two modalities.

The meta-analysis by Sayegh and Strauch, one of the most comprehensive quantitative analyses available, concluded that both open and endoscopic techniques yield comparable outcomes in terms of symptomatic improvement and recurrence rates, although the endoscopic approach may be associated with faster functional recovery in the early postoperative period. Nevertheless, neurological complication rates—although low for both techniques—remain an inherent concern. In this context, if open surgery does not demonstrate clinical inferiority compared with the endoscopic approach, optimization of the skin incision and the plane of ligament division becomes particularly relevant from a safety perspective.

I. Anatomical Variability and Surgical Risk. One of the key determinants of procedural safety in carpal tunnel release is the distal anatomical variability of the median nerve. The classification proposed by Lanz systematizes this variability into four principal patterns, emphasizing modifications in the course of the recurrent motor branch (RMB), the presence of accessory branches, and high divisions of the median nerve.

The surgical relevance of this classification lies in the observation that most potentially vulnerable variants are located in the radial sector of the carpal tunnel, the region where the RMB typically emerges to innervate the thenar musculature. In transligamentous and subligamentous patterns (Type I), as well as in high divisions (Type III), sectioning of the transverse carpal ligament along the midline or with radial deviation may expose atypical neural trajectories to direct injury (Figure 6).



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Multiple anatomical studies have confirmed that the RMB may follow unpredictable courses, including variants that traverse the ligament or emerge in more radial positions than usual. This anatomical unpredictability renders incision planning a critical component of surgical safety.

II. Implications for the Choice of Approach: Contemporary discussion should not be confined to the dichotomy of “open versus endoscopic surgery,” but rather extended to the anatomical optimization of the open approach. Although the endoscopic technique has been associated in some series with reduced early postoperative pain, it has not demonstrated sustained superiority in long-term functional outcomes. Therefore, open surgery remains a valid and widely utilized alternative.

Within this framework, ulnar displacement of the incision, as proposed in the Tanzer technique, is grounded in the concept of an “anatomical lower-risk zone.” By distancing the incision from the radial sector—where the majority of Lanz-described variants are concentrated—the potential risk of injury to the recurrent motor branch and accessory branches may be reduced.

From an anatomical standpoint, the ulnar side of the carpal tunnel presents a lower density of critical nerve variants compared with the radial sector. This principle supports the Tanzer incision as a rational strategy aimed at neurological preservation, particularly in situations in which the presence of an anatomical variant cannot be anticipated preoperatively. The various open incisions and their characteristics are summarized in Table 1.

III. Pillar Pain and Approach-Related Morbidity: Pillar pain represents one of the most frequently reported complications following open carpal tunnel release. Comparative evidence suggests that its incidence may be more closely related to the extent of dissection and the degree of tissue trauma than to the specific type of approach itself. In this regard, a properly localized incision that respects anatomical safe zones and minimizes deep radial manipulation may indirectly contribute to reducing postoperative morbidity.

In the present case, surgical planning took into account the potential distal anatomical variability of the median nerve, even though no evident variant was identified intraoperatively. Selection of an ulnar-displaced approach allowed adequate exposure of the transverse carpal ligament with direct visualization of the median nerve and its branches, without neurological complications. Although a single case does not permit definitive conclusions, it illustrates the practical applicability of the anatomical principles discussed.

IV. Limitations: The principal limitation of this review lies in the methodological heterogeneity of the available studies and the scarcity of comparative clinical trials specifically analyzing incision localization within open carpal tunnel surgery. Most anatomical data derive from cadaveric studies, whose clinical extrapolation must be undertaken with

caution. Furthermore, current evidence does not allow for the establishment of absolute superiority of one incision over another, but rather supports inferences based on anatomical plausibility and risk analysis.

V. Clinical Implications: The Lanz classification provides a robust anatomical framework for understanding the potential risks associated with carpal tunnel release. In the absence of demonstrated long-term superiority of the endoscopic technique, the safety of the open procedure depends largely on detailed knowledge of anatomical variability and on the selection of an approach that minimizes exposure of vulnerable structures.

From this perspective, the Tanzer incision may be considered an anatomically reasoned alternative within the armamentarium of open techniques, particularly in the hands of surgeons who prioritize direct visualization and structural control of the operative field.

Table 1. Anatomical and surgical comparison of the main open incisions in carpal tunnel release					
Incision Type	Location and path	Relationship with the recurrent motor branch (RMB)	Potential risk of nerve injury	Vascular risk (superficial palmar arch)	Key advantages
Classic central longitudinal	Palmar incision over the axis of the third finger or between the third and fourth fingers	Near the radial emergence of the RMB	Moderate-high in Type I and III variants (Lanz)	Moderate if it extends distally	Excellent visualization; reproducible technique
Radial curvilinear (Taleisnik type)	Curved incision toward the thenar eminence	Close to the usual path of the RMB	High, especially in transligamentous pathways	Low to moderate	Easy access to the retinaculum
Mini-central incision (mini-open)	Short incision in the palmar midline	Similar to the central longitudinal branch	Moderate (visualization dependent)	Low	Less early pain; rapid recovery
Ulnar incision (Tanzer)	Short longitudinal incision, ulnar to the axis of the ring finger, proximal to Kaplan's line	Far from the radial sector where the RMB emerges	Low-moderate (less exposure to radial variants)	Low if it respects Kaplan's line	Based on the "least risk anatomical zone"; good reproducibility
Modified zigzag or Bruner incision	Broken path following palmar creases	Variable depending on displacement	Moderate	Low	Better adaptation to skin folds

AUTHOR CONTRIBUTIONS

Yuliet Guadalupe Sánchez-Javier: conceptualization, project administration, supervision, writing – original draft, writing – review and editing. **Kevin Adrian Tinajero-Camacho:** formal analysis, resources, software, writing –

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review and editing. **Felipe Alarcón-Estrada:** investigation, methodology, resources. **Mariana Vanesa Guzmán-Tejeda:** investigation, methodology, resources. **Alejandro Herbert Oliva-Arvizu:** investigation, methodology, resources. **José Alfonso Simental-Andrade:** investigation, methodology, resources. **Esteban Marrufo-Sumano:** investigation, methodology, resources. **Abner Amiel Cortes-Gorozpe:** investigation, methodology, resources. **Sebastian Javnel Jimenez-Fuentes:** investigation, methodology, resources. **Eduardo Balboa-Hernández:** investigation, methodology, resources.

DECLARATION OF CONFLICT OF INTEREST

The author declares that he has no conflict of interest related to this article.

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CONSENT

The patient provided written informed consent for the publication of this case report and any related images.

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