Joint Diseases and Related Surgery

Jt Dis Relat Surg
2026;37(2):510-518

ORIGINAL ARTICLE

The effect of WALANT on outcomes of flexor tenolysis

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ABSTRACT

Objectives: This study aims to evaluate the outcomes of the flexor tenolysis cases with wide-awake local anesthesia no tourniquet (WALANT) and to compare them with cases with other anesthesia types.

Patients and methods: Between March 2004 and March 2024, a total of 104 patients with 150 fingers with flexor tenolysis (71 males, 33 females; mean age: 32.67 ± 11.64 years; range, 16 to 62 years) were included in the study. The WALANT group consisted of 41 patients with 53 fingers, while the conventional anesthesia group consisted of 63 patients with 97 fingers. Pre- and postoperative total active motion (TAM) gains were compared between the two groups and relevant factors were investigated.

Results: Overall TAM gain was 47% in our study cohort. The TAM gain was 55% and 43% in the WALANT group and in the conventional anesthesia group, indicating a statistically significant difference (p = 0.005). The best TAM gains were observed in the clean-cut injury type. The TAM gains were better in the cases without fractures. Age was a significant factor in the tenolysis outcomes, and younger patients had improved outcomes.

Conclusion: Our study results indicate a significant difference in the TAM gain between the WALANT and conventional methods. Taken together, we believe that the application of WALANT in tenolysis of flexor tendon adhesions represents a significant advancement in hand surgery. The ability to perform the procedure under local anesthesia while allowing for immediate assessment of tendon function enhances the surgical precision and results.

Keywords: Flexor tendon, tenolysis, wide-awake local anesthesia no tourniquet, wide-awake.

The incidence of tenolysis after flexor tendon surgery is approximately 5 to 15%, even if updated and adequate techniques are used.[1,2] Various elements play a role in the development of peritendinous adhesions, such as the initial injury to the tendon and its surrounding sheath, the technical details of the surgical repair, and the immobilization of the tendon during the rehabilitation phase.[3] Flexor tenolysis is an established surgical procedure to restore mobility to the flexor tendon by lysing adhesions that inhibit tendon gliding and negatively impact functional outcomes following flexor tendon repair.[3] While there are reports regarding the tenolysis outcomes are often unsatisfactory and suboptimal with re-adhesions and other complications,[4] literature contains reports that support favorable outcomes can be achieved by tenolysis.[5,6]

The wide-awake local anesthesia no tourniquet (WALANT) technique has been increasingly used for various hand surgeries, including flexor tendon repairs.[7] Studies have reported lower tenolysis rates after flexor tendon repair under WALANT compared to traditional anesthesia, although the results were not statistically significant.[8] In addition, WALANT has been shown to reduce postoperative pain and opioid use, which can be beneficial for patients.[9]

Received: September 05, 2025
Accepted: November 21, 2025
Published online: March 17, 2026

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Citation: Güntürk ÖB, Meral DD, Yener C, Erol K, Koca A. The effect of WALANT on outcomes of flexor tenolysis. Jt Dis Relat Surg 2026;37(2):510-518. doi: 10.52312/jdrs.2026.2600.

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Wide-awake tenolysis is described in the literature[10] and numerous procedures such as carpal tunnel release, trigger finger release or flexor tendon repair performed with WALANT were described in the literature.[11,12] However, fewer information and case series exist about performing tenolysis under WALANT.

Although tenolysis is not the most commonly performed procedure within the WALANT cases in the literature, it is the most commonly performed procedure with WALANT in our hospital. In the present study, we hypothesized that WALANT constituted an effective approach, particularly for tenolysis, as the intraoperative adequacy of tenolysis could be evaluated solely through the active motion of the flexor tendon. We, therefore, aimed to evaluate the outcomes of flexor tenolysis cases with WALANT and to compare them with cases of other anesthesia types.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at EMOT Hospital, Department of Orthopedics and Traumatology, Division of Hand Surgery between March 2004 and March 2024. Prospectively collected patient records of our hospital were scanned. Inclusion criteria were as follows: All injury types with flexor tenolysis, additional procedures such as arthrolysis, pulley reconstruction, and extensor tenolysis, if the procedures were performed to enhance flexor tenolysis and continuation to the physiotherapy protocol. Exclusion criteria were as follows: Patients younger than 16 years old, patients with a follow-up duration of < 6 months, cases with arthrolysis, pulley reconstruction and extensor tenolysis, if the procedures were performed without flexor tenolysis, cases with additional procedures such as corrective osteotomy, arthrodesis, repairs for ruptured flexor tendons and cases which required secondary operations that disrupts the proper physiotherapy program, such as debridement and reconstruction for infection or skin necrosis. Data scanning revealed 167 patients who underwent the tenolysis surgery. Sixty-three patients with follow-up period of less than six months were excluded from the study; thus, 104 patients with 150 fingers (71 males, 33 females; mean age: 32.67 ± 11.64 years; range, 16 to 62 years) were included in the study. The WALANT group consisted of 41 patients with 53 fingers, while the conventional anesthesia group consisted of 63 patients with 97 fingers. All surgeries were performed by a single orthopedic or hand surgeon who had at least level-three experience according to the criteria of level of expertise.[13] Pre- and postoperative data were recorded from the patient files. A written informed consent was obtained from each patient. The study protocol was approved by the EMOT Hospital Ethics Committee (Date: 16.09.2024, No: 2024/005). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Surgical technique and physiotherapy

Tenolysis surgery at our clinic is indicated when there is inadequate finger total active motion (TAM) which affects the patient's daily life and when physiotherapy has reached a plateau. Additionally, the total passive motion should exceed the TAM, and soft-tissue equilibrium should be established. All surgeries were performed in the operating room and no office procedures were performed. The choice of the anesthesia technique was made as follows: Cases before the first WALANT case in 2017 were performed under axillary block or general anesthesia. Subsequently, choices were discussed with the patient, WALANT was offered, and the decision was made according to the patients' consent. The WALANT technique was used according to the steps described by Tang.[10] Axillary block or general anesthesia and tourniquet were used in the other group. Tenolysis technique was similar between the two groups consisting of first releasing the flexor tendons from the surrounding tissues and, then, releasing the flexor digitorum profundus (FDP) and flexor digitorum superficialis (FDS) from each other if available. The differentiating part is to check the active motion. In the WALANT cases, the patient was asked to flex and extend his or her finger and the tenolysis level was continued until sufficient motion was achieved (Cases in figures 1, 2 and 3). In the other group, active motion was checked by either extending the incision to the normal proximal tendon level (Figure 4a) or by making a separate proximal incision and pulling the tendon to flex the joints (Figure 4b). After completing the tenolysis, pulley reconstruction was performed if gross bowstringing occurred, and arthrolysis was performed if joint contractures were present.

All patients were followed by an experienced hand therapist, starting on the first day after tenolysis. Physiotherapy was performed twice daily for the first three weeks. The details of the physiotherapy protocols are listed in Table I.

The postoperative examination values were based on the last follow-up visit. The TAM was

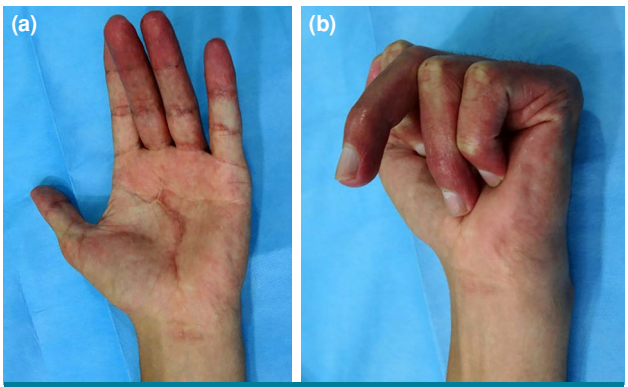


FIGURE 1. Preoperative view of a patient before 3rd finger flexor tenolysis. **(a)** Extension view with slight deficit. **(b)** Active flexion.

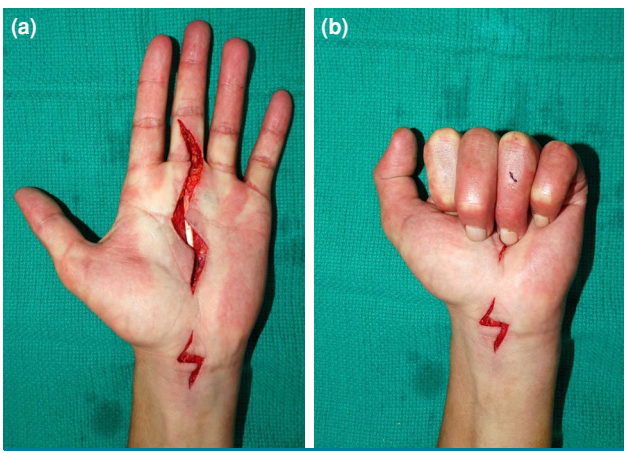


FIGURE 2. Intraoperative view of the case in figure 1 after tenolysis with WALANT. **(a)** Extension view. **(b)** Active flexion.
WALANT, wide-awake local anesthesia no tourniquet.

calculated as the sum of active flexion of the distal interphalangeal (DIP), proximal interphalangeal (PIP), and metacarpophalangeal (MP) joints and subtracting the extension deficits of the DIP, PIP, and MP joints. Comparisons regarding the TAM were performed for the number of fingers (n = 150) and not the number of patients (n = 104), as the values of the fingers were different in most of the multiple-finger cases.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 24.0 software (IBM Corp., Armonk, NY, USA). Continuous data were presented in mean ± standard deviation (SD) or median (min-max), while categorical data were presented in number and frequency. The distribution of the range of motion (ROM) measurements from the operated fingers was assessed for normality using the Kolmogorov-Smirnov test, which indicated that the data followed a normal distribution. Parametric tests were used for further analyses. Mixed-design analysis of variance (ANOVA) was used to examine the differences between preoperative and postoperative TAM measurement values and the interactions with group factors. Following significant differences ($p < 0.05$), Bonferroni post-hoc tests were conducted for pairwise group comparisons. The Bonferroni test was applied to control the type 1 error rate, when multiple comparisons were performed, adjusting the p-values to provide more reliable

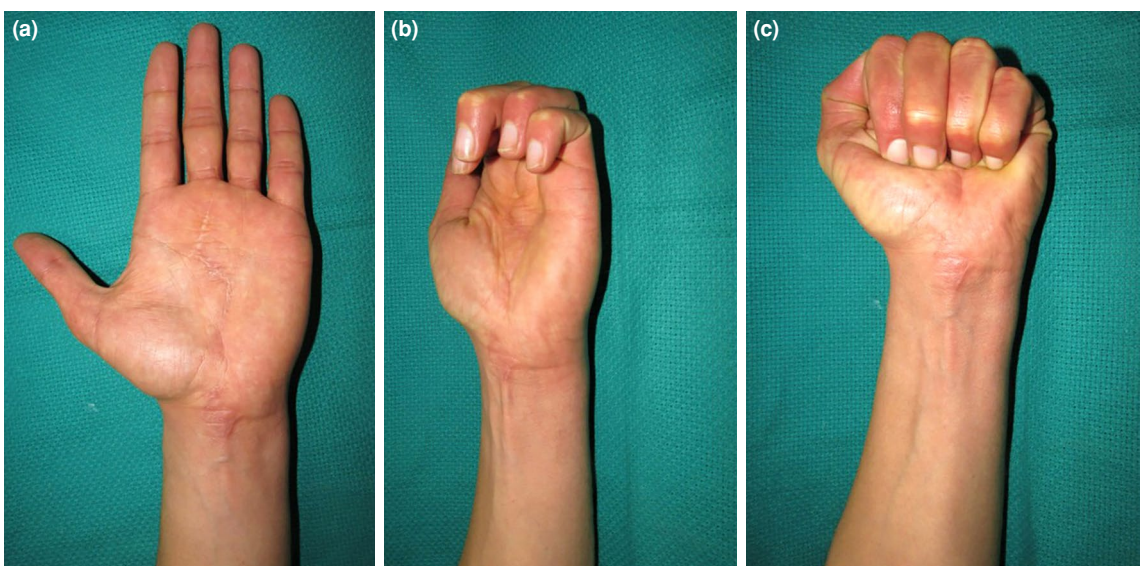


FIGURE 3. Postoperative view of the case in figures 1 and 2. **(a)** Extension **(b)** PIP and DIP flexion **(c)** Full flexion.
PIP, proximal interphalan; DIP, distal interphalangeal.

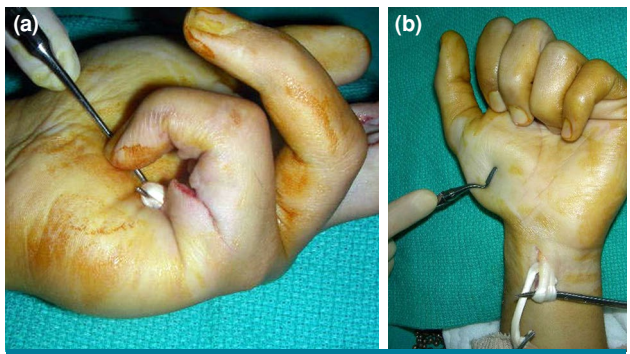


FIGURE 4. Checking the sufficiency of tenolysis in non-WALANT cases. **(a)** Traction control by extending incision and pulling the tendon. **(b)** Pulling the FDP tendons from a separate proximal incision (The tendon at the left side is the FDS tendon of the 4th finger which was already ruptured and non-repaired from the initial surgery and resected in the time of tenolysis).
WALANT, wide-awake local anesthesia no tourniquet; FDP, flexor digitorum profundus; FDS, flexor digitorum superficialis.

results. The relationship between age, time to tenolysis, and preoperative and postoperative TAM differences was assessed using the Spearman correlation analysis. The Spearman correlation was used to evaluate the non-linear relationship between these variables. To determine whether there were differences between the WALANT and other anesthesia groups for continuous variables, independent sample t-tests were applied. For categorical variables, the chi-square test was used to assess group differences based on anesthesia type. A p value of < 0.05 was considered statistically significant.

RESULTS

Injuries occurred on the dominant side in 57 patients (55%). The median time from the initial operation to tenolysis was 10 (range, 4 to 44) months. The median follow-up time after the tenolysis was 11 (range, 6 to 17) months.

Seventy (67%) patients underwent surgery in our hospital at the time of the initial injury, and 34 (33%) patients were referred from other hospitals for tenolysis.

The FDP was repaired in all patients during initial surgery. Furthermore, fracture fixation was

TABLE I
Physiotherapy protocol for tenolysis patients

Period	Applications
Postoperative 1st week	• Edema control: Use of arm sling, elevation, coban bandage wrapping, cold application • Wound care: Dressing of the surgical area should be protective but thin enough not to hinder movement • AROM exercises (after 24 h) • Pain control • Home program
Postoperative 2-3 weeks	• After stitches are removed, whirlpool bath, scar massage • Continued edema control • AROM, AAROM, PROM exercises • Tendon gliding exercises • If necessary, block splints to support tendon gliding • Guidance for light daily activities
Postoperative 4-6 weeks	• Active stretching exercises • If necessary, careful passive stretching exercises according to surgical content • NMES, to support tendon gliding • Ultrasound, for scar management • Gentle strengthening exercises starting from the 6th week • If PROM is insufficient, application of dynamic splint
Postoperative 7-8 weeks	• Functional assessment • Resistance exercises after the 8th week
Postoperative 8-12 weeks	• Gradual return to work planning according to the patient's job scope

AROM, active range of motion; AAROM, active assisted range of motion; PROM, passive range of motion; NMES, neuromuscular electric stimulation.

also performed in 35 patients, and 19 cases had total or near-total amputations which were replanted. Initial injuries were classified into clean-cut, local crush, extensive crush, and degloving/avulsion types, and the number of patients was 29, 33, 32, and 10, respectively.

Tenolysis was performed on one finger in 71 patients, and multiple fingers were involved in 33 patients. Among the 150 fingers, tenolysis was performed mostly for the index finger (47 fingers, 31%), followed by the long, ring, little, and thumb fingers (43, 32, 24, and 4 fingers, respectively).

Majority of the flexor tendons (124 fingers, 83%) were injured in the second zone in the initial injury, followed by third and fourth zones (17 and 9 fingers, respectively). There were no cases of tenolysis for injuries in the first or fifth zones.

Data regarding age, sex, finger, zone, injury type, additional injuries, time to tenolysis, and additional procedures were similar between the two groups ($p > 0.05$). Detailed data for the two groups are presented in Table II. The mean preoperative TAM was 116.53 degrees in all patients. There was a 47% gain, and the postoperative mean TAM was 165.83 degrees (Figures 5 and 6). The TAM

TABLE II
Detailed data regarding the two groups

	WALANT			Other anaesthesia types			
	n	%	Mean	n	%	Mean	*p*
Age (year)			32.62			33.1	0.80
Sex							0.13
Male	32			70			
Female	21			27			
Finger							0.21
Thumb	1			3			
Index	19			28			
Middle	16			27			
Ring	6			26			
Small	11			13			
Zone							0.07
2	47			77			
3	6			11			
4	0			9			
Additional injury							0.59
Only soft tissue laceration	23			41			
Fracture fixation	21			33			
Injury type							0.43
Clean-cut	15			19			
Local crush	16			27			
Extensive crush	18			37			
Degloving-avulsion	4			14			
Time to tenolysis (month)			12.26			8.59	0.27
Additional procedures							0.86
Pulley reconstruction	5			5			
Arthrolysis	11			20			
Pulley reconstruction + arthrolysis	1			3			
Extensor tenolysis	2			5			
Preoperative TAM (degrees)			124.72			112.06	**0.005**
Postoperative TAM			185.47			155.10	
TAM gain (degrees)			60.75			43.04	
TAM gain (%)	55				43		

WALANT, wide-awake local anesthesia no tourniquet; TAM, total active motion.

gains were better in the WALANT anesthesia group comparing to other anesthesia group, the difference was statistically significant ($p = 0.005$). Moreover, TAM gain rate in the WALANT group was 55% and it was 43% in the other anesthesia group.

One finger in the WALANT group and five fingers in the other anesthesia group had no gain of TAM, two fingers in the WALANT group, and three fingers in the other anesthesia group had worse postoperative results.

Apart from comparisons between the two groups, factors affecting the overall success rate of tenolysis were also investigated. The best TAM gains were observed in the clean-cut injury type, followed by extensive crushing, local crushing, and degloving/avulsion (gains comparisons; $p = 0.023$). The TAM gains were significantly higher in the soft tissue laceration group, worse in the fracture fixation group, and worst in the replantation group (gains comparisons; $p = 0.029$). Age was a significant factor in the tenolysis outcomes and correlated inversely with TAM gain ($p < 0.001$).

Sex, finger, zone, time to tenolysis, and additional procedures had no significant effect on TAM gain ($p > 0.05$).

DISCUSSION

In the present study, we evaluated the outcomes of flexor tenolysis cases with WALANT and compared them with cases of other anesthesia types. Our study results showed that overall TAM gains are significantly better in cases with WALANT. These findings suggest that WALANT is a reliable option for flexor tenolysis.

The discussion surrounding tenolysis in flexor tendon surgery, particularly under the WALANT technique, has gained traction in recent years owing to its implications for surgical outcomes and patient satisfaction. Tenolysis is often required following flexor tendon repair due to the formation of adhesions that can impede tendon gliding and functional recovery. The introduction of WALANT has provided a novel approach to this surgical challenge, allowing for real-time assessment of tendon function during the procedure, which has been expected to enhance postoperative outcomes. Our initial WALANT case in this series was conducted in 2017. Since then, we have increasingly opted for WALANT in tenolysis procedures. Currently, our standard approach is to offer WALANT as the first option to all

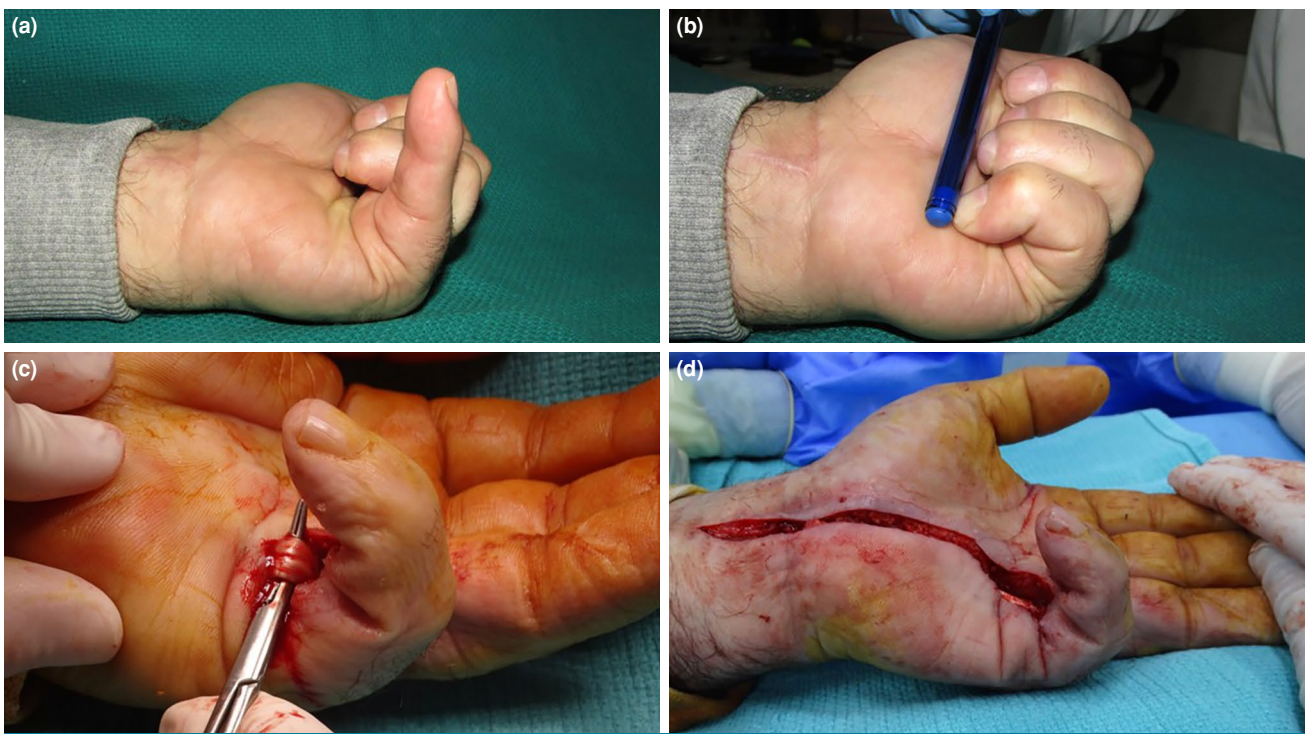


FIGURE 5. WALANT tenolysis case in a previously repaired 5th FDP with tendon graft. **(a)** Pre-tenolysis active flexion. **(b)** Pre-tenolysis passive flexion. **(c)** Release after zone 2 and distal zone 3, finger flexion is present with tendon traction but absent with active flexion. **(d)** Active flexion is achieved after releasing proximally to zone 5.
WALANT, wide-awake local anesthesia no tourniquet; FDP, flexor digitorum profundus.

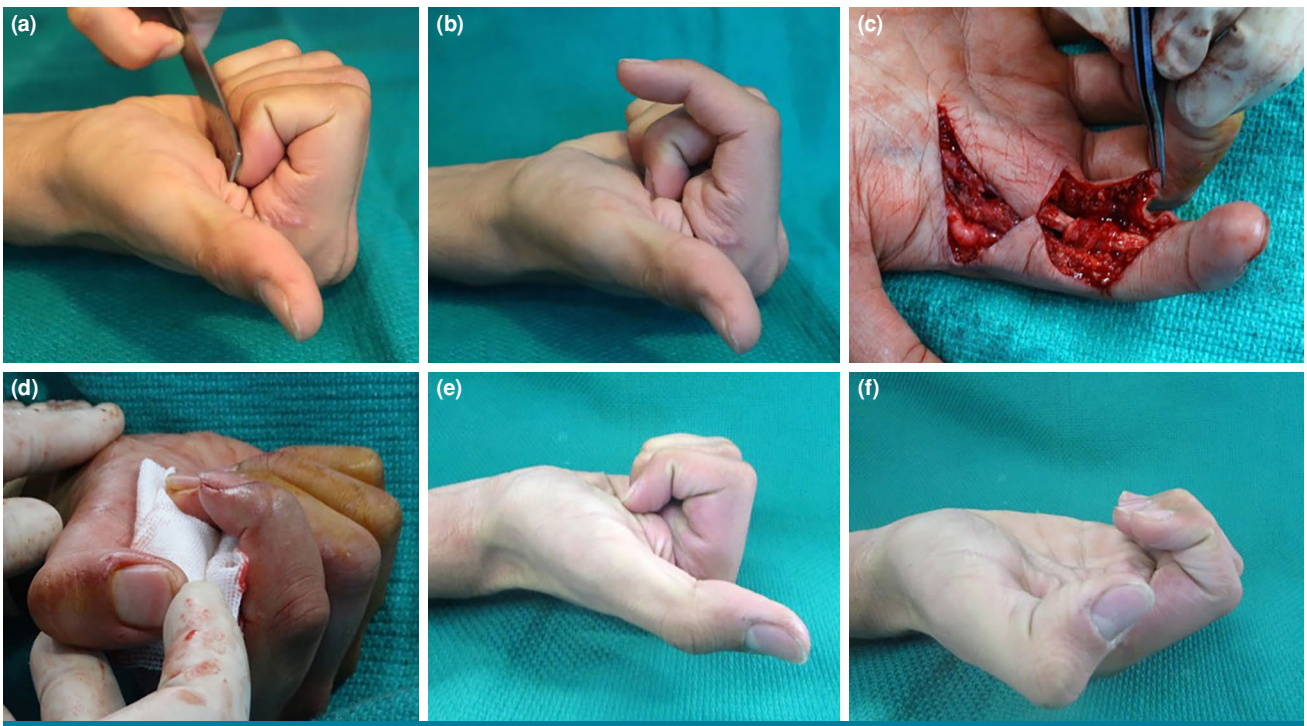


FIGURE 6. WALANT tenolysis case in a previously repaired 2nd FDP and FDS. **(a)** Pre-tenolysis passive flexion. **(b)** Pre-tenolysis active flexion. **(c)** Intraoperative view of tenolysis. **(d)** Intraoperative check of the active flexion. **(e)** Postoperative active flexion of all finger joints. **(f)** Postoperative active flexion of PIP and DIP joints.

WALANT, wide-awake local anesthesia no tourniquet; FDP, flexor digitorum profundus; FDS, flexor digitorum superficialis; PIP, proximal interphalangeal; DIP, distal interphalangeal.

patients. Our non-WALANT tenolysis cases are limited to those patients who prefer not to undergo wide-awake surgery.

The WALANT technique allows surgeons to perform tenolysis while the patient is awake, facilitating immediate intraoperative feedback regarding tendon mobility. Tang[10] described and advised wide-awake tenolysis, although no patient information was provided. In another report including 12,000 patients in two centers, only 12 tenolysis cases show-up in one center, and elective tendon repair and tenolysis case count was 52 in the other center. There was no outcome data either.[14] Ghoraba et al.[15] reported that this technique enables the surgeon to assess the ROM of the fingers immediately after tenolysis, which can be crucial for determining the success of the procedure and planning postoperative rehabilitation. They state that the real-time assessment is particularly beneficial in complex cases where the extent of scarring and adhesion formation can vary significantly, and they presented the patient outcomes of the tenolysis. However, they reported outcomes for a specific procedure (tenolysis and interpositional free tissue transfer) in 22 patients. They achieved improvement in 20 patients. Gonzalez-Torres et al.[16] presented a pediatric case report about performing tenolysis with WALANT and reported that using WALANT in flexor tendon repair was widely reported, while tenolysis data are limited and most of them are among the adult patients. The review of the literature reveals the notion that the use of WALANT for tenolysis is feasible, but the data are limited. This may be due to the low frequency of tenolysis procedures compared to other WALANT cases. In our study, we report outcomes of 104 tenolysis cases, including 41 WALANT cases. This represents a significant number of cases in the literature for this particular subject. Our technique is not an invention, but reporting the success of WALANT in tenolysis is a critical milestone for the literature.

The main technical advantage of performing tenolysis under the WALANT technique is the ability to intraoperatively assess whether the level of tenolysis is sufficient. To illustrate, in a patient who had previously undergone flexor tendon repair with a tendon graft, active motion remained inadequate

after tenolysis at zones 2 and 3. However, traction testing demonstrated improved flexion. This finding suggested that the limitation was not solely at the distal level and might have remained unrecognized without the use of WALANT. Proximal continuation of the tenolysis until adequate active flexion was achieved revealed that the adhesions extended proximally to zone 5 (Figure 5). Another advantage of WALANT is that the surgeon can demonstrate finger movement to the patient during the procedure. In the early postoperative period, swelling and inflammation frequently cause temporary stiffness, which may negatively affect patient motivation at the first physiotherapy session. Observing active finger movement during surgery can enhance patient motivation and facilitate earlier engagement with physiotherapy.

On the other hand, the WALANT technique is not without its drawbacks. One issue is the potential for technical challenges, such as bleeding, which may obscure the surgical field and lead to procedural delays. Another concern is patient anxiety, which may limit tolerance of wide-awake surgery. Furthermore, it is recommended that patients with pre-existing conditions such as scleroderma, Raynaud's disease, Buerger's disease, or vasculitis be carefully evaluated and potentially excluded from WALANT surgery.[17]

Apart from the WALANT, the results of flexor tenolysis present a complex landscape of outcomes, influenced by various factors, including the surgical technique employed and the timing of intervention. Studies have consistently shown that the TAM improvement following tenolysis is a primary measure of success. Breton et al.[18] reviewed 40 patients and reported a mean increase in TAM of 60° after tenolysis. However, the complication rates associated with tenolysis remain a significant concern. Rosenblum et al.[4] highlighted the limitations of traditional tenolysis approaches, noting issues such as wound complications and re-adhesion phenomena which can undermine the benefits of surgery. Furthermore, the findings of Demers et al.[3] indicated that trauma to adjacent tissues significantly increases the risk of adhesion formation, thus necessitating tenolysis in the first place. This suggests that careful preoperative assessment and management of tissue integrity are essential for improving outcomes. Moreover, outcomes vary based on the tenolysis context, such as after grafting, where the need for subsequent tenolysis due to adhesions is common.[5] Our series encompasses a range of cases from simple lacerations to replanted crush amputations. The overall mean increase in TAM was 47% following tenolysis (Figure 6). In the non-WALANT group, there was a 43% improvement in TAM. Our aim is to demonstrate that WALANT may provide superior results; however, this does not imply that tenolysis performed under other forms of anesthesia is ineffective. We advocate that tenolysis with or without WALANT is beneficial for patients; however, not all patients experienced positive outcomes. There are three cases in the WALANT group and eight patients in the other group who did not gain TAM. Upon examining these patients for reasons behind the failures, we identified that most, but not all, of their initial injuries were crush injuries rather than simple lacerations, despite no correlation being obtained regarding the injury type. Likewise, cases with fractures or replantation had significantly worse outcomes, but three of the no-gain cases were soft tissue-only lacerations. Therefore, exact outcomes cannot always be predicted. Nevertheless, we recommend tenolysis to all patients who lack motion for daily living activities and have not shown improvement even after achieving tissue equilibrium.

Limitations include retrospective design, the possibility of different tissue reaction for stiffness among the patients and the possibility of differences between surgical techniques of different surgeons.

In conclusion, our study results indicate a significant difference in the TAM gain between the WALANT and conventional methods. Based on these findings, we believe that the application of WALANT in tenolysis of flexor tendon adhesions represents a significant advancement in hand surgery. The ability to perform the procedure under local anesthesia while allowing for immediate assessment of tendon function enhances the surgical precision and results. As the body of evidence supporting WALANT continues to grow, further research is warranted to optimize techniques and protocols, ensuring that patients receive the best possible care in the management of flexor tendon injuries.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Ö.B.G., K.E.: Researched literature and conceived the study; D.D.M.: Was involved in protocol development; C.Y.: Involved in data analysis; Ö.B.G.: Wrote the first draft of the manuscript. All authors reviewed and edited the manuscript and approved its final version.

Conflict of Interest: The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding: The authors received no financial support for the research and/or authorship of this article.

AI Disclosure: The authors declare that artificial intelligence (AI) tools were not used, or were used solely for language editing, and had no role in data analysis, interpretation, or the formulation of conclusions. All scientific content, data interpretation, and conclusions are the sole responsibility of the authors. The authors further confirm that AI tools were not used to generate, fabricate, or 'hallucinate' references, and that all references have been carefully verified for accuracy.

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