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# To Do or Not to Do? Neurorrhaphy in Great Toe Pulp Flap Fingertip Reconstruction

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**Background:** Since its inception, the great toe pulp (GTP) flap has represented a valid therapeutic choice in the reconstruction of defects of the hand. This study illustrates the clinical outcomes of GTP free flaps performed without nerve anastomosis, mainly for fingertip defect reconstruction.
**Methods:** We performed a retrospective, monocentric cohort study. All patients included in this study presented with fingertip traumatic injury, with tendon or bone exposure; reconstruction with GTP flap, without nerve reconstruction, was performed by the first author (L.T.) from May 2019 to October 2021.
**Results:** All 37 flaps survived completely. Due to COVID restrictions, we had to send the tests and PROMs to our patients; 28 of them replied. Cold intolerance was reported by 12 patients (moderate in two cases and mild in ten cases). No pain was complained about either in hand or donor site (Visual Analog Score 0, at rest and at movement). Complete range of motion was achieved in 22 of 28 patients. All flaps recovered protective sensitivity. In every section of the Michigan Hand Outcome Questionnaire, all patients expressed a high level of satisfaction based on the reconstruction's function and aesthetics. Regarding the donor site morbidity, no patient complained about gait disturbance.
**Conclusions:** This study showed that the GTP flap is the optimal choice for fingertip reconstruction, providing excellent functional and aesthetic results with durable and glabrous skin, satisfactory pulp contour, and sensory restoration. These results could be achieved with no need for nerve suture, especially in defects with no injuries proximal to the loss of substance. *(Plast Reconstr Surg Glob Open 2022;10:e4539; doi: 10.1097/GOX.0000000000004539; Published online 30 September 2022.)*

## INTRODUCTION

Soft tissue reconstruction of the hand, especially of the fingertips, poses a real challenge for the reconstructive surgeon.[1–3] Fingertips have an unquestionable value in hand function,[4] but their defects, although small in size, create a disproportionately large discomfort.[5] Due to the unique characteristics of the hand skin, both functional and aesthetic aspects must be considered in the reconstruction planning.[6]

The magnitude of the problem represented by fingertip injuries is reflected in the wide range of reconstructive possibilities described in the literature, including bone shortening and skin closure, secondary intention healing, and skin grafting. This magnitude is also reflected in the wide spectrum of local flaps, neurovascular pedicled flaps, and microsurgical procedures described in the literature.[5] The choice of the single modality among the multiple options of the reconstructive armamentarium depends not only on the characteristics and dimensions of the loss of substance but also on patient preference and wills, functional demanding and request, general condition, culture, and expertise of the surgeon.[9]

Regarding the microsurgical reconstructive procedures, the first flaps harvested from the foot for the

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reconstruction of the hand date back to the 1960s. The first microsurgical transfer from toe to thumb in a monkey was performed by Buncke et al[16] in 1966, then in a man by Cobbet[17] in 1968. These types of transfer opened a large field in reconstructive surgery, suggesting that flaps harvested from feet and toes could be designed to reconstruct hand defects with overall satisfactory functional and aesthetic outcomes.[18] Since its original inception by Buncke and Rose[19] in 1979, the free lateral great toe pulp (GTP) flap has been characterized as providing a glabrous skin paddle based on the first dorsal metatarsal artery and dorsal superficial vein.[20,21]

The purpose of this study was to investigate clinical outcomes of GTP flaps performed without nerve sutures for the reconstruction of fingertip defects.

**Takeaways**

**Question**: Have we found the ideal flap to reconstruct pulp digital defects?

**Findings**: The GTP flap provides a "like-with-like" reconstruction of the pulpar area of the digits, with low donor site morbidity and adequate sensitivity recovery.

**Meaning**: The GTP flap is one of the best options to reconstruct the pulp area of the digits, even without nerve anastomosis.

## METHODS

We performed a retrospective, monocentric, cohort study, based on reconstructive microsurgery service, University Department of Hand Surgery and Rehabilitation in MultiMedica Hospital, Milan, Italy. All patients included in this study showed fingertip traumatic injury, with tendon or bone exposure, and reconstruction with GTP flap, without nerve reconstruction, performed by the first author (L.T.), from May 2019 to October 2021.

We evaluated the functional and aesthetic outcomes for at least a 3-month follow-up. Different patient-related outcome measures were submitted to the patients, in particular:

1. Michigan Hand Outcome Questionnaire;
2. Pain visual analog score, to assess pain both at the donor site and at the fingertip;
3. Cold Intolerance Severity Score, to stratify cold intolerance.

The finger appearance and donor site morbidity were assessed subjectively by the patient. The recovery of sensation of digital pulp was examined using static two-point discrimination (2PD) test. The range of motion (ROM) of the reconstructed finger was recorded.

Summary statistics were calculated. Quantitative data are expressed as the mean ± SD, whereas nominal data are expressed as a percentage.

### Surgical Technique

Informed consent was obtained from the enrolled patients to use their archived data, including the assessment forms and photographs before and after the surgery. The flap was designed on the lateral side of both proximal and distal phalange of the great toe, according to the size and shape of the finger defect after the proper debridement.

We preoperatively identify the location of the vessels by a hand doppler in the donor and the recipient areas. Surgery was performed with the patient under general anesthesia, aided by pneumatic tourniquet control.

The incision was placed distally in the first web space to visualize the junction of the tibial digital artery of the second toe and the fibular digital artery of the great toe,[22] paying attention to the superficial veins[9] (Fig. 1). Unlike the technique proposed by Wei et al,[23] the retrograde dissection of the vascular pedicle was performed exclusively dorsally, without affecting the plantar side (Fig. 2). The length of the harvested flap artery and vein depended on the distance between the pulp defects and the corresponding structure selected as the recipient vessels of the injured finger. The arterial anastomosis was performed between the proper digital artery of the injured finger and the first dorsal metatarsal artery. The venous anastomosis was performed between the vein of the dorsal or volar subcutaneous system of the finger and a comitans vein. The anastomoses were performed in end-to-side or end-to-end fashion. In some cases, it was necessary to use a vein graft. No nerve suture was performed.

In case of nail bed lesion, the flap was placed to reconstruct the pulp defect with the flap skin paddle and the nail bed with the GTP adipose tissue.[7] The donor site could have generally been closed primarily.

## RESULTS

Between May 2019 and October 2021, the GTP flaps were applied in fingertip reconstruction for 37 fingers in 37 patients (34 men and three women), with a mean age of 39.4 (range, 17–72) years. The GTP flap was used for the reconstruction of all the fingers, particularly the dominant hand's first two fingers.

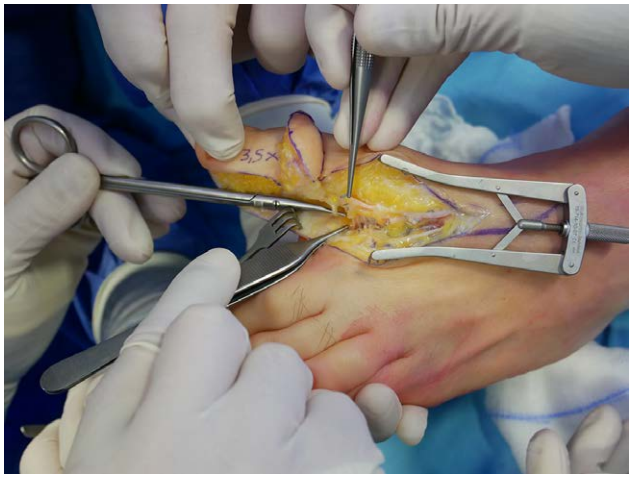


**Fig. 1.** GTP flap intraoperative view.

The smallest flap size was 1.5×1.5 cm, and the largest flap was 3.5×2.5 cm (Figs. 3, 4). We used progressively shorter pedicles, and the average pedicle length was 4.1 (range, 2–11) cm. Arterial anastomoses were performed in end-to-end fashion and end-to-side fashion: 13.5% end-to-side anastomosis and 86.5% end-to-end anastomosis, with the use of a vein graft in three fingertip reconstructions (8%; harvested from the donor site in all the cases).

The mean ischemia time was about 1 hour (59.9±12.73 minutes), whereas the entire surgical procedure lasted about 4 hours (238.5±60.10 minutes). Only one reconstruction needed arterial anastomosis revision. The mean length of stay was 6.34 (±3.25) days.

The GTP flap was used for recontruction of both acute and chronic injuries [mean time from injury to reconstruction 41.7 (from 1 to 411) days]. The follow-up time ranged from 90 to 702 days (mean time is over 1 year, 368.1 days). Thirty-six of 37 donor sites were closed primarily; only one was closed with a skin graft. Regarding the donor site morbidity, no patient complained about gait disturbance or about the great toe scar that is conveniently hidden and without contact with the floor during ambulation.

Survival rate was 100%. Further surgical procedures (nail or scar revision) were performed in 13 patients (35%).

Due to COVID restrictions, tests and patient-related outcome measures could not be performed and were submitted to only 28 of all the patients (75.68%). In every section of the Michigan Hand Outcome Questionnaire, all patients expressed high levels of satisfaction with the reconstruction's function and aesthetics (average score, 88.78/100; range, 77.17–96.62/100). Cold intolerance was reported by 12 patients (42.86%), classifiable according to Cold Intolerance Severity Score as moderate in two cases and mild in 10 cases.

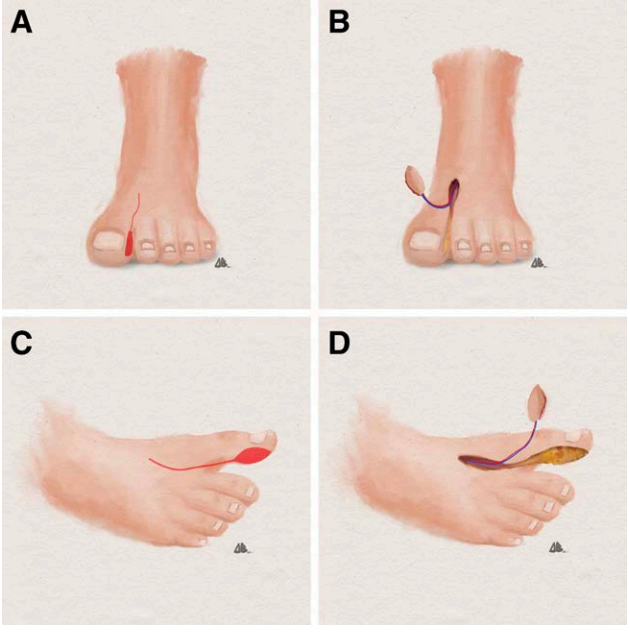


**Fig. 2.** Illustration of the design and harvest of the GTP flap. A and B, Frontal view. C and D, Lateral view.

The 2PD average score was 9.41 mm. Particularly, in patients with a follow-up period less than 4 months, the 2PD average score was 11.5 mm, while in patients with more than a 4-month follow-up period, it was 8.37 mm. A 2PD average score of 10.33 mm was achieved in patients with history of extensive trauma, including injuries of several structures (bones and tendons), while a 2PD average score of 6.41 mm was obtained in patients with isolated fingertip amputation.

No pain was reported about hand and donor site (Visual Analog Score 0, at rest and movement). Twenty-two of 28 patients achieved a complete ROM, with no limitation in active or passive mobility. (**See Video [online]**, which displays functional and aesthetic outcomes of right thumb reconstruction with GTP flap after 12 months.) Nevertheless, the ROM evaluation did not prove to be a valid indicator of reconstruction outcomes, given the associated underlying injuries. Of these underlying injuries, phalangeal fractures or tendon injuries had a direct and, arguably, the most remarkable impact on the finger ROM.

Four flaps (14.28%) provided only protective but not discriminative sensation. Patients report the appearance of initial protective sensitivity, especially for heat and cold, on average 3.5 months after surgery. Almost all patients (97.30%) were able to return to work in the average time of 9 weeks (range, 0–24).

## DISCUSSION

Replantation is the first-choice treatment option in fingertip injuries.[7] However, when it is not a viable therapeutic option, fingertip defects can be addressed with various flaps, from local and pedicle flaps to microsurgical procedures. All proposed therapeutic alternatives aim to respect the plastic surgery principle—replacing like with like—to restore an adequate functional and aesthetic pulp contour of the digit, provide thick and glabrous skin coverage, allow protective sensation, prevent claw nail deformity, and minimize the sacrifice of the donor site.[1,7,8]

Among the reconstructive options, full-thickness skin grafts offer an easy solution, but are far from ideal, not providing either durable skin resurfacing or protective sensation.[7] Local flaps (V-Y advancement flap, homodigital and heterodigital flaps, and thenar and hypothenar flaps) offer a consistent donor site morbidity close to the site of injury. Other disadvantages are limited flap mobility (up to 2 cm), need for prolonged immobilization, and need for secondary or multiple surgical procedures.[10–13]

The homodigital flap provides a conspicuous scar and a potential sacrifice of the neurovascular bundle.[2] The cross finger flap proved to be a reliable technique, helpful to restore extended and volar oblique defects of any digit. However, this technique involved denting an otherwise noninjured finger, provided a limited recovery of sensibility, and needed cortical reorientation.[11] The main drawback of the cross finger flap, thenar flap,[14,15] and hypothenar flap[9] is the risk of flexion contracture of the finger due to the immobilization period.[8]

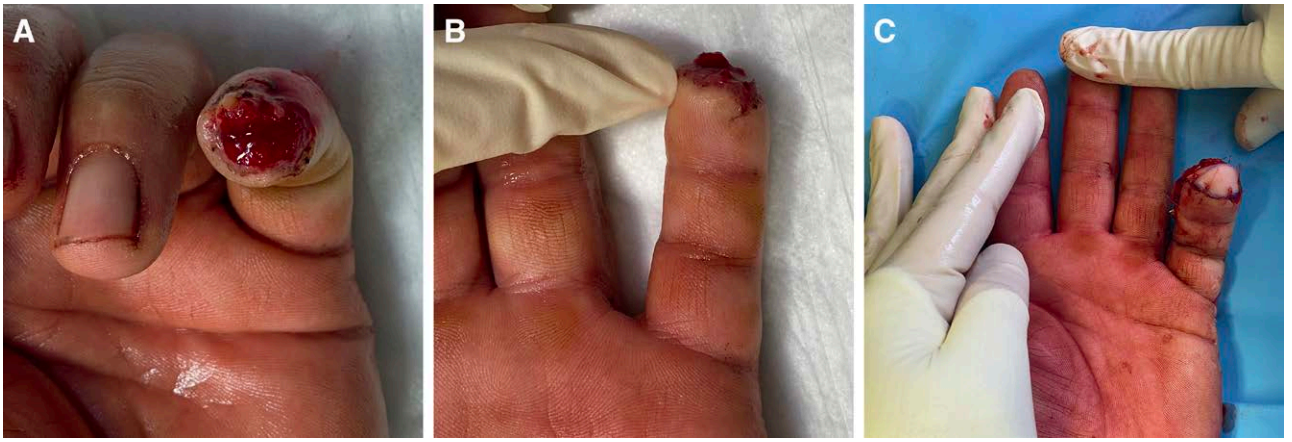


**Fig. 3.** Clinical example of fingertip transverse amputation and its reconstruction. A and B, A 43-year-old man with amputation of the tip of the fifth finger. C, Flap inset, immediate postoperative result.

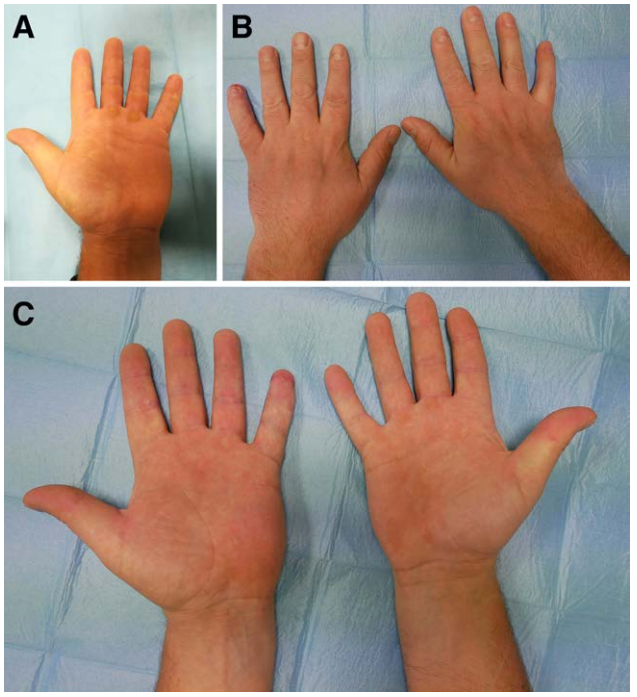


**Fig. 4.** Follow-up after 3 months (A–C).

Several attempts of an algorithmic approach to fingertip reconstruction options have been proposed based on level, size, shape, the direction of soft tissue defect,[24,25] and Allen classification.[10] Given that the foot and toes offer an optimal donor site, different therapeutic solutions were described, from graft taken from the fibular site of the great toe,[5,26–28] to second tibial toe pulp flap.[29] In this panorama of reconstructive surgical options, the advantage of the GTP flap is to fully respect the like-with-like principle, providing tissue match with glabrous skin, fat lobule architecture, deep papillary ridges, and fibrous septae that radiate from the periosteum to the skin to minimize shearing and slippage with gripping. It also allows the addition of a nail component in case of nail bed injury,[4,30] with minimal donor site morbidity.[24]

During the past decades, the indications of GTP flap reconstruction have expanded, going from complete digital pulp loss in the thumb[31] or defect involving two-thirds of the pulp of the first three fingers,[32] especially in young patients,[33] to the reconstruction of adequately sized defects when local or regional flaps were not viable[34] (Figs. 5, 6). The increasing use of the GTP flap is also due to its excellent reliability and survival rate.[1] In our study, the success rate was 100%.

The sensation is the essential element for fingertips to be involved in hand functions. The restoration of a long-lasting pain-free skin cover with suitable sensation to a significant pulp defect may be the most crucial aspect of the final functional outcome.[35,36]

Compared with local options, the GTP flap provides better sensory recovery, with improved 2PD[16,23,37] and precise stereognosis[35] due to cutaneous sensory receptor of high density.[2,12] The factors that affect the sensibility results are considered to be age, follow-up period, and sensory reeducation.[1] Lee et al[29] and Kato et al[38] proposed a correlation between age and recovery of sensation, considered more satisfactory in less than 35 years of age. In our series, we did not find differences between the age groups.

Association between sensation recovery results and the follow-up period is commonly regarded as positive,[1] with a progressive improvement, which stabilizes in some months. This pattern was confirmed in our study; indeed, we found a poor sensation recovery in all patients with a less than 4-month follow-up period (mean 2PD score in less than 4-month follow-up period 11.5 mm versus mean 2PD score in more than 4-month follow-up period 8.37 mm).

The fingertip reconstructions with GTP flap documented in the literature suggest that one of the key factors for sensory recovery consists of an adequate nerve suture,[12] with nerve fascicle of similar number and quality as the recipient site[9,30,37] (Table 1). On the other hand, based on evidence concerning the spontaneous recovery of sensation in free flaps,[39-41] the fingertip reconstructions described in this study were performed without nerve suture, obtaining a 2PD average score of 9.41 mm. In particular, only partial and limited sensation recovery

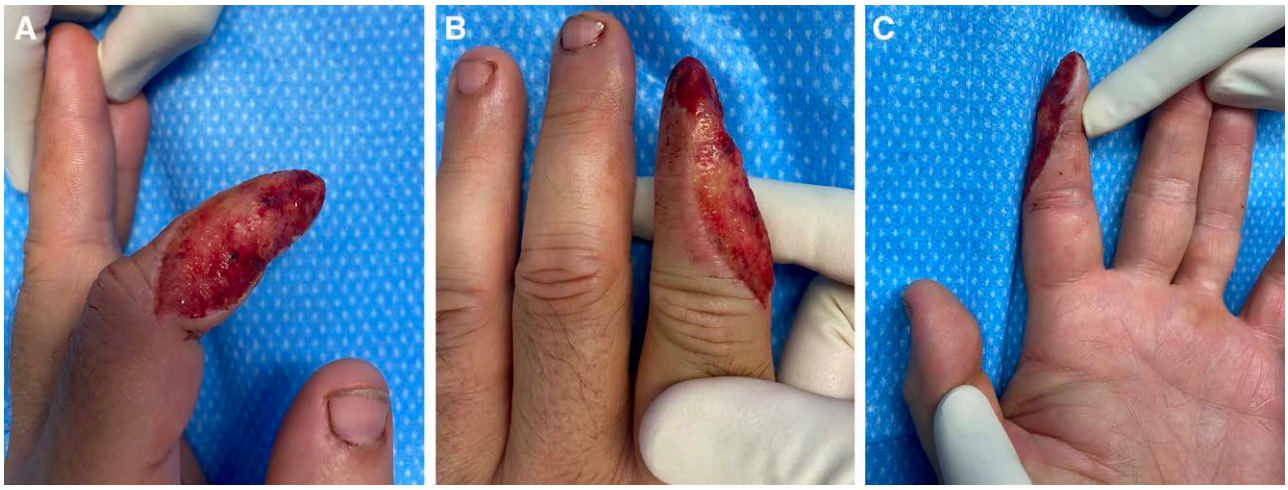


**Fig. 5.** Clinical example of a digit oblique amputation with significant loss of fingertip substance. A–C, A 51-year-old man with oblique amputation of the second finger.


**Fig. 6.** Follow-up after 12 months (A–C).

(2PD average score, 10.33 mm) was achieved in the case of extensive trauma, with injuries of several structures, such as phalanges fractures or tendon injuries, or involving the whole finger, the other fingers, or the hand. On the contrary, in the case of solely fingertip soft-tissue injuries (Allen pattern 2 and 3), associated at most with tuft fractures, the discriminative sensitivity recovery was better (2PD mean score, 6.41 mm). In these patients, the results obtained are superimposable to reconstruction with GTP flaps and free flaps from toes and foot performed with nerve suture documented in the literature.

These data suggested that the nerve suture may not be an essential element for sensory recovery, especially in small-sized flaps bounded by noninjured tissue.[39] Therefore, in more extensive traumas with high-energy dynamics and injuries proximal to the reconstruction site, it could be helpful to verify if nerve sutures could promote nerve regeneration and permit a better recovery of the discriminative sensation.

An element of undoubted usefulness in the recovery of sensation remains an early rehabilitation program, starting about 1 week after the surgical procedure.[30] Cortical reeducation and adaptation due to continuous and regular use of reconstructed finger, spontaneous or supervised occupational therapy, lead to improvement in two-point discrimination test results,[1] with better sensation in the flap than in the donor site.[30]

An advantage of the surgical technique derived from this study is the possibility to harvest a short vascular pedicle through a unique dorsal incision by providing more rapid

**Table 1. Literature Review**

| Authors | Donor Site | Case (n) | Follow-up (mo) | Static 2PD (mm) |
|---|---|---|---|---|
| Wang et al[37] | Great toe and second toe | 15 | 34.8 | 7.13 |
| Balan[4] | Great toe and second toe | 7 | 9 | 6.5 |
| Yuan et al[3] | Great toe | 24 | 20 | 5 |
| Gu et al[12] | Great toe and second toe | 21 | 18.4 | 4.8 |
| Zheng et al[2] | Great toe | 32 | 22.8 | 6.17 |
| Spyropoulou et al[10] | Great toe and second toe | 17 | 35 | 10.5 |
| Deglise and Botta[32] | Great toe and second toe | 8 | 20-74 | 7 |
| Tan et al[30] | Great toe and second toe | 13 | 32.1 | 6.8 |

flap elevation,[29] less donor site morbidity with less scarring, and less risk of pedicle kinking[10] without injuries and incisions to the foot sole and to the weight-bearing areas. Nevertheless, this technique is not free from drawbacks; in the recipient site, the anastomoses should be performed close to the zone of injury on small diameter vessels, and in the most distal part of the vessel where spasm is frequently described.[10] Moreover, in the donor site, the anatomical variation of the vascular supply, especially of the dorsal vein, could complicate the flap harvesting.[1,2]

## CONCLUSIONS

In conclusion, abiding by the prime reconstructive principle of replacing like with like, the GTP flap is an excellent choice for digital pulp reconstruction. Indeed, it provides clinical outcomes superior to local flaps, with excellent functional and aesthetic results, durable and glabrous skin, satisfactory pulp contour, and sensory restoration. These results could be achieved with no nerve suture, especially in distal defects with no injuries proximal to the loss of substance.

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