Review Article
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Skin Closure After Subtotal Aponeurectomy in Severe Dupuytren's Contracture: Review

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One of the significant problems of surgical treatment of Dupuytren's contracture is skin deficiency after subtotal aponeurectomy. There are many options for skin grafting after subtotal aponeurectomy. However, there is no consensus on surgical approach to an altered palmar aponeurosis and on the choice of method for replacing soft tissue defects, taking into account the severity of the disease and the number of rays involved in the pathological process. The aim of the study was a comparative analysis of skin plasty methods after subtotal aponeurectomy in patients with Dupuytren's contracture stages III-IV. The review analyzes various treatment tactics, including preliminary distraction elimination of contracture in the external fixation devices followed by aponeurectomy, as well as various methods of skin plasty methods formed after excision of altered areas of palmar aponeurosis and elimination of contracture. In the early stages of the disease, Z- and V-Y plasty are sufficient. In patients with severe degree of the disease, more complex techniques have to be used due to large skin defects that cannot be covered with local tissues. Each of the proposed methods of surgical treatment has its advantages and disadvantages. An analysis of the literature has shown that the most common method of soft tissue plasty after aponeurectomy is Z-plasty. However, as the severity of the disease increases, its effectiveness decreases. To date, there is no consensus regarding surgical approach to an altered palmar aponeurosis and the choice of technique for soft tissue plasty in the Dupuytren's contracture stages III–IV.

Keywords: palmar fibromatosis, Dupuytren's contracture, Dupuytren's disease, skin plasty, subtotal aponeurectomy.

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Восполнение дефицита кожного покрова после субтотальной апоневрэктомии при контрактуре Дюпюитрена тяжелой степени: обзор литературы

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Одной из существенных проблем хирургического лечения контрактуры Дюпюитрена является дефицит кожного покрова при ушивании раны после субтотальной апоневрэктомии. Существует множество вариантов пластики кожи, однако нет единого мнения о доступе к измененному ладонному апоневрозу и о выборе способа замещения дефектов мягких тканей с учетом тяжести заболевания и количества лучей, вовлеченных в патологический процесс. Целью обзора является сравнительный анализ методов пластического восполнения дефицита кожи после субтотальной апоневрэктомии у пациентов с III-IV степенью заболевания. В обзоре анализируются различные тактики лечения, включая предварительное дистракционное устранение контрактуры в аппарате внешней фиксации с последующей апоневрэктомией, а также различные способы пластического замещения дефектов кожи, образующихся после иссечения измененных участков ладонного апоневроза и устранения контрактуры. На ранних стадиях заболевания достаточно Z- и V-Y-пластики. У пациентов с тяжелой степенью заболевания приходится использовать более сложные методики из-за больших дефектов кожи, которые невозможно укрыть местными тканями. Каждый из предлагаемых способов хирургического лечения имеет свои преимущества и недостатки. Анализ литературы показал, что самой распространенной методикой восполнения дефицита мягких тканей после апоневрэктомии является Z-пластика. Однако по мере увеличения степени тяжести заболевания ее эффективность снижается.

Ключевые слова: ладонный фиброматоз, контрактура Дюпюитрена, болезнь Дюпюитрена, пластика кожи, субтотальная апоневрэктомия.

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BACKGROUND

The treatment of Dupuytren's contracture stages III-IV is a difficult task for specialists, since after aponeurectomy and elimination of the contracture of the joints of the fingers, significant skin defects are formed that require plastic replacement [1]. There are many options for skin plastic surgery after subtotal aponeurectomy. However, there is no consensus on the access to the altered palmar aponeurosis and the choice of a method for replacing soft tissue defects, taking into account the disease severity and the number of rays involved in the pathological process [2].

According to international and Russian experts, subtotal aponeurectomy is the gold standard for the treatment of Dupuytren's contracture [3, 4]. Despite this, in recent decades, more and more articles have focused on minimally invasive treatment methods (needle aponeurotomy and enzymatic aponeurotomy) [5, 6]. First of all, this is due to a large number of early and late postoperative complications that range from 3.6% to 46.0% and the complexity of the plastic stage of the surgery for large skin defects [7, 8, 9]. Despite the low number (1-2%) of complications of minimally invasive methods of treatment, the recurrence rate with their use is 80-90% during the first 3 years after manipulation, while the recurrence rate with subtotal aponeurectomy reaches 34% [5, 6, 7, 8, 9].

Taking into account the contracture duration with a pronounced disease stage, which can reach 10-15 years from the appearance of the first signs until the patient seeks help, the skin on the palmar surface of the hand shrinks inevitably, which determines the need to compensate for its deficiency after the contracture is eliminated. When planning the surgical intervention, the surgeon must consider the solution of several questions, namely, 1) which access to choose, 2) how to avoid skin necrosis during its detachment, and 3) how to replace the skin defect formed?

To date, there is no consensus among specialists on the method of replacing defects in the skin of the hand after aponeurectomy in stages III–IV of the disease. This review aimed to conduct a comparative analysis of various methods of plastic replacement of skin deficiency after subtotal aponeurectomy in patients with stages III-IV of the disease.

EPIDEMIOLOGY AND SOCIAL SIGNIFICANCE

To date, the prevalence of Dupuytren's disease varies greatly. Its incidence data varied in different countries [10]. According to the UK hand surgery centers, the prevalence of Dupuytren's contracture is 32.5 per 100.000 populations per year [11], it is 20% of all hand diseases in Germany, 11.8% in Russia, 8.8% in France, and only 2-3% in the USA [12]. The highest prevalence of this pathology is registered in Scandinavia, where it reaches 46% in people aged >60 years [13], and the lowest incidence was revealed among people of African and Asian origins [13, 14, 15, 16, 17]. Such a wide range of values depends mainly on the ethnicity, sex, and age of the patients. In the vast majority of cases (92-96%), middle- and old-age men are affected by palmar fibromatosis [18, 19].

In 67% of patients engaged in manual labor, the rapid progressive course of this disease leads to severe impairment of professional activity and, in 3% of cases, to a sustained disability, which is not only a medical but also a socioeconomic problem [20, 21].

In addition to the most common form of Dupuytren's contracture, many experts distinguish a special type of this pathology, known as fibrous diathesis, or Dupuytren's diathesis. This disease is characterized by a more aggressive course, manifests itself at a young age, affects several fingers and the radial side of the hand, and occurs bilaterally. It is characterized by the presence of nodules on the dorsal surface of the interphalangeal joints (often proximal interphalangeal joints, PIP), the so-called Garrod pads; positive family history (the presence of this disease in close relatives, such as the father, mother, etc.); combination with Peyronie's and Ledderhose's diseases; and tendency to recurrence and progression [22, 23].

CLASSIFICATIONS

The main criteria for the classification of palmar fibromatosis are the localization of the pathological process on the hand and the severity of flexion contracture of the metacarpophalangeal and interphalangeal joints of the fingers involved in the pathological process [24].

In 1993, Volkova proposed her classification of Dupuytren's contracture according to the following parameters:

1. By prevalence

– finger shape, which is characterized by flexion contracture of the PIP and extensor contracture in the distal interphalangeal joint (DIP);

– palmar form, which is characterized by flexion contracture of the metacarpophalangeal joint (MCP);

– a mixed form (palmar-finger), when changes are registered on both the palm and fingers.

2. According to the flexion contracture stage, where stage I corresponds to 0-70°; stage II, 71-139°; and stage III, ≥140°.

3. According to the clinical course (primary form, secondary (relapse) form, mixed (relapse and progression) form) [25].

However, the classification proposed by Tubiana is more often used as the most acceptable and convenient [26]. In this classification, five disease stages are distinguished:

– Stage 0: presence of clinical signs of the disease in the form of nodules in the palm without contracture of the fingers.

– Stage I: total flexion contracture of the fingers of 0–45°.

– Stage II: total flexion contracture of the fingers of 45-90°.

– Stage III: total flexion contracture of the fingers of 90-135°.

– Stage IV: total flexion contracture of fingers of >135° [26, 27].

Both classifications are similar and take into account only the total contracture of the joints of the fingers, whereas neither of them takes into account the number of rays involved, which also determines the disease severity.

Zhigalo et al. proposed a classification of Dupuytren's contracture, which takes into account all the aspects of this disease, i.e., stage, shape, and number of affected rays [28]. The authors divided the classification into the following parameters:

1) According to the localization of the pathological process: right hand, left hand, and both hands.

2) By damage to the rays of the palmar aponeurosis: rays 1, 2, 3, 4, and ray 5.

3) According to the finger joints involved in the contracture: MCP as palmar form (palma); PIP or DIP as dactylar form (digitus); MCP+PIP or DIP as palmar-dactylar form (PD); MCP+PIP+ DIP as total form (total).

4) According to the contracture severity, where 0 corresponds to nodules/strands on the palm; 0I, restriction of overextension; stage I, 0-45°; stage II, 45-90°; stage III, 90-135°; and stage IV, 135-180°.

To explain this classification, the authors cited a clinical example with a standard formulation of the diagnosis and coding according to the proposed option, namely, stage III Dupuytren's contracture of the left hand with a predominant lesion of ray 5 and palmar-dactylar form of stage III Dupuytren's contracture of the left hand (L5C-PD-III). According to the authors, the use of the proposed coding for the diagnosis of Dupuytren's contracture saves time when filling out medical documentation and makes the diagnosis understandable in any language, which simplifies the communication between specialists from different countries [28]. However, this classification has not yet been widely used.

TREATMENT OF DUPUYTREN'S CONTRACTURE

The treatment of extremely severe Dupuytren's contracture is a difficult task. Various approaches for the treatment of this category have been proposed. In general, all treatment options for Dupuytren's contracture can be divided into surgical (open) interventions, minimally invasive (closed) techniques, and conservative methods. However, since our review focused on methods of replacing skin defects after aponeurectomy, we analyzed only surgical techniques. In the range of the surgical methods for the treatment of Dupuytren's contracture, there are radical (total), segmental, and subtotal (partial) aponeurectomy [7, 29].

Radical aponeurectomy is the only method that has only historical significance. This method was used in the 1950s–1960s. The essence of the method consisted of the complete removal of the entire palmar aponeurosis (normal and altered) on the hand and fingers to prevent disease recurrence and progression. However, this surgery has not become widely used because of its complications, such as postoperative hematoma, prolonged wound healing, complex regional pain syndrome, which prolonged the rehabilitation.

With *segmental aponeurectomy*, a small fragment (up to 1 cm) of the altered tissue is excised through a C-shaped or linear skin incision along the pathological strand. This enables the formation of a defect between the strand ends, which excludes the possibility of their fusion and subsequent contraction. This technique is indicated for stage I-II Dupuytren's contracture with a predominant lesion of the MCP, which eliminates the need for skin plastic surgery after aponeurectomy. Moreover, contracture can be eliminated with minimal postoperative risks with a short recovery period [30].

Subtotal aponeurectomy is currently the most common surgical treatment for Dupuytren's contracture. Access to the altered areas of the aponeurosis is performed through skin incisions of various shapes and lengths [3, 4, 6]. In most cases, specialists strive to suture the wounds primarily, but in the presence of skin deficiency, some authors leave separate areas of wounds open for secondary healing [31, 32, 33], particularly when performing aponeurectomy using McCash's method proposed in 1964 [34]. The authors who prefer this approach note decreased complications associated with postoperative hematoma and wound infection. However, these patients require long-term follow-up and frequent dressings; in addition, the rehabilitation process is prolonged due to the long-lasting healing of wounds on the hand [35].

The incidence of complications after subtotal aponeurectomy ranges from 6% to 46% (damage to nerves, arteries, infectious complications, postoperative hematoma, complex regional pain syndrome, etc.) [36]. One of the causes of the complications, in addition to age and comorbidities, is seeking medical help by patients at a late disease stage, when there is a significant limitation of hand function [37]. In their study, Bulstrode et al. showed a direct correlation between the number of complications and disease stage, with the largest number of them in patients with stages III-IV [38].

Given all of the above, specialists should solve the following problems:

1) Skin deficiency that occurs after the elimination of severe contracture.

2) Correction of PIP contracture caused by secondary changes in para-articular tissues.

3) Prevention of postoperative complications.

Taking into account the problems that arise during subtotal aponeurectomy with a pronounced stage of the disease, two options for solving these problems are described:

1) Distraction method for eliminating contracture followed by aponeurectomy.

2) Simultaneous elimination of the contracture of the joints of the fingers, followed by the replacement of the skin defects of the hand.

Staged treatment of severe Dupuytren's contracture (stages III–IV)

The two-stage technique is based on the elimination of the contracture of the finger joints by the distraction method in the external fixation apparatus. Gradual distraction reduces the stage of contracture by stretching the skin and para-articular structures. The next stage is an aponeurectomy. Numerous options for external fixation apparatus have been proposed; this approach helps avoid the need for plastic replacement and avoid joint arthrolysis [39, 40].

This technique has some advantages, such as the gradual lengthening of the skin and para-articular tissues, which facilitates the performance of subtotal aponeurectomy, but does not eliminate the need for plastic repair. Despite this, prolonged distraction in the external fixation apparatus is associated with the risk of complications, such as infectious (wire and rod osteomyelitis), limitation of mobility in the PIP, and skin ruptures. In addition, treatment takes a long time, which increases the costs and reduces patient satisfaction. At present, this technique has not yet been widely used.

One-stage treatment of Dupuytren's contracture

Methods for replacing hand skin defects after aponeurectomy can be divided into several types, namely, the use of a free full-thickness skin graft, local skin grafting, and regional grafts [41, 42, 43, 44, 45].

Plastic repair with a full-thickness skin graft

In the case of recurrence of contracture or Dupuytren's diathesis in young patients, some experts prefer to use a full-thickness skin graft (FTSG) to compensate for skin deficiency after the contracture of the finger joint has been eliminated. Several international studies have shown

that the skin from another part of the body, free of myofibroblasts, involved in the formation of pathological changes in the aponeurosis, prevents disease progression, creating a kind of barrier, known as a "firebreak" [46, 47, 48].

Ullah et al. conducted a prospective randomized study to evaluate the number of relapses of PIP contracture after dermofasciectomy and skin defect replacement with FTSG. The study included 79 patients. PIP contracture averaged 59° and MCP contracture averaged 21°. The patients were distributed into two groups: Group 1 included 39 patients who underwent Z-plasty after aponeurectomy and Group 2 included 40 patients who received FTSG after dermofasciectomy. Subjective and objective assessment of hand function was performed at months 3, 6, 12, 24, and 36. Wound healing and functional recovery in both groups were approximately the same. However, in one patient with Z-plasty, marginal necrosis of the graft was detected, and in four patients with FTSG, an insignificant separation of the wound edges was revealed. None of the cases required re-intervention. The mean movement amplitude in the PIP joints improved to 65° (from 2° to 98°) over 3 years in both groups of patients. At 36 months after surgery, no significant difference was found in the number of disease recurrences in the groups analyzed (11 cases in total with 5 patients in Group 1 and 6 patients in Group 2). The technique described is not free from shortcomings, such as the risk of graft rejection and the need for an additional incision to harvest the graft [46].

Plastic surgery with local tissues

Uemura et al. conducted a retrospective analysis of the postoperative results of treatment of 23 patients with stage I-III Dupuytren's contracture (25 hands and 29 fingers), who underwent subtotal aponeurectomy, and Y-V- and Z-plasty were used to compensate for skin deficiency. The postoperative follow-up period ranged from 6 to 32 (average, 12) months. Clinical results were assessed by improving the extension in each joint in accordance with the Tubiana classification [27]. The authors reported that the wounds were sutured primarily in all cases. There were no postoperative complications, except for one patient who developed complex regional pain syndrome. His symptoms were arrested using oral steroids, which eventually led to a good outcome. Contracture was reduced on average from 46.5° preoperatively to 4.2° postoperatively for MCP and from 43.9° to 22.4° for PIP, with a mean percentage improvement of 92% for MCP and 56% for PIP. In 83% of cases, it was possible to achieve positive results and reduce the number of early and late postoperative complications [49]. Considering that the study included patients only with disease stages I-III, the method proposed by the authors does not cover completely the defect in the severe disease stage, which is one of the most difficult issues for specialists, because the complexity of the plastic stage of the surgery increases.

The advantages of Z-plasty were also demonstrated by Magomedov et al. in a study on the replacement of hand skin defects after subtotal aponeurectomy in the treatment of 86 patients. A zigzag incision and cutting out opposing triangular grafts provide good visualization of pathologically altered segments of aponeurosis and neurovascular bundles and eliminate flexion contracture of the fingers. In all cases, it was possible to close the wounds primarily, which reduced significantly the proportion of early postoperative complications to 0.9-1.0% [50]. However, the study lacks data on the magnitude of MCP and PIP contracture before surgery, and there is no information on the nature of complications or data on the stage of contracture correction.

Le Gall and Dautel proposed an original technique for filling the skin deficiency of the proximal phalanx in severe Dupuytren's contracture with localization mainly on the fifth finger. This method was initially tested on cadaveric material (12 upper limbs). The authors artificially formed a skin defect in the region of the proximal phalanx of the fifth finger, corresponding to the skin deficiency after the elimination of contracture in stages III-IV of the disease. This technique included variants of local grafts, namely, the Houston, Coulson, and wide-based grafts (the methods are known and described in the literature regarding the replacement of hand skin defects). The clinical study included 10 patients with stage II-IV Dupuytren's contracture and predominant lesion of PIP. In all cases, after aponeurectomy and elimination of the vicious position of the fingers, the skin defect was replaced according to the proposed method. In all pa-

tients, the wounds healed by primary intention, and there were no cases of skin necrosis of the grafts, separation of the wound edges, infectious complications, or other complications associated with the healing process. In the postoperative period, it was possible to achieve the correction of MCP contracture up to 4.2° on average and up to 22.4° for the PIP joint. The average follow-up period was 9.5 months. In 83% of cases, successful results were achieved. The authors believe that the use of the proposed technique helps obtain a larger tissue volume than did Y-V- and Z-plasty and thus achieve fewer complications associated with wound healing and more satisfactory aesthetic and functional results in the long-term [2]. Although the authors achieved optimal results, a study on a larger group of patients is required to obtain significant statistical data.

Regional grafts

An alternative option for filling skin defects in the region of the main phalanx is cross-skin grafting (cross-plasty) from the adjacent finger or using an islet graft on the dorsal metacarpal artery. Spindler et al. presented a clinical case of the use of cross-plasty to fill the deficiency of the skin of the proximal phalanx after aponeurectomy on the fifth finger in a recurrent form of the disease. Before surgery, the MCP contracture was 15° and that of PIP was 100°. After excision of the altered aponeurosis, the lack of skin of the main phalanx was 3.5 × 2.5 cm. To eliminate it, a fasciocutaneous cross graft was cut from the adjacent finger according to the defect size, and a FTSG taken from the inner surface of the shoulder was used to close the donor area. According to the authors, after 4 months, excellent functional and aesthetic results have been achieved [37].

Large skin defects of the proximal phalanx can also be replaced with an islet graft on the dorsal metacarpal artery. Ekerot operated on 15 patients with a recurrent disease, who underwent replacement of the skin defect using this method after the removal of pathological strands. All patients in this group previously underwent the surgery repeatedly (the number of surgeries in history was 1.6 on average). Before surgery, the total contracture averaged 77°. Some patients required PIP joint release and additional transarticular wire fixation to maintain the joint extension. The rehabilitation period ranged from 3 to 5 months. According to the author, there was not a single case of complete loss of the graft; however, in four cases, marginal necrosis of the distal part of the graft was noted, which did not require additional intervention. One patient had subtotal graft necrosis due to venous insufficiency, which was the reason for repeated surgery. A graft on the dorsal metacarpal artery was also used to replace the defect. In 15 patients, it was possible to achieve correction of PIP contracture by an average of 15° [51].

The problem of replacing soft tissue defects during surgery for contracture recurrence, when the skin in the intervention site is scarred, is of greatest interest. According to Spindler et al., to obtain good esthetic and functional results in skin defects of the proximal phalanx, it is more expedient to use blood-supplying tissue complexes, particularly a wide-based graft from the adjacent finger (cross-plasty) [37]. The disadvantage of this method consists in damage to the adjacent finger and the need to collect FTSG to replace the donor defect. In this case, a more preferred option is an islet graft on the dorsal metacarpal artery, since in this case, an additional graft is not needed, and the donor wound is sutured in line. This method enables obtaining excellent aesthetic and functional results, as demonstrated by Ekerot [51].

In Dupuytren's contracture, the fourth–fifth fingers are more often affected. Methods for plastic replacement of defects on these fingers were presented above. Areas of the palmar aponeurosis are affected less commonly along rays 1–3. The literature describes a limited number of cases of replacement of skin defects of the palmar surface of the hand and the first, second, and third fingers after aponeurectomy. With this disease localization, careful preoperative planning is required to determine the expected skin defect size and choose the method of its replacement after the contracture has been eliminated. Interestingly, Seyhan focused on filling the deficit of soft tissues in the palm with an islet reversible perforant thenar graft after aponeurectomy in seven patients. The blood flow to this graft is supplied by the perforating vessel of the superficial palmar arch or the radial branch of the superficial palmar arch. Using this graft, a defect of 2.5×6.5 cm can be replaced with primary suturing of the donor wound without any consequences,

for example, adduction contracture of the first finger or the formation of a rough scar. The average follow-up period for patients was 12.6 months. In one case, due to venous stasis, marginal necrosis of the graft developed, which did not affect the final result. The author managed to obtain excellent cosmetic and functional results in all patients who underwent surgery. According to the author, the indication for the use of this graft is a defect located on the palm, the palmar surface of the main phalanx of the first, second, or third finger, in the area of the first interdigital space [52].

CONCLUSIONS

The literature analysis showed that despite the achievements of modern medicine, the treatment of patients with stage III-IV Dupuytren's contracture remains an urgent problem. The elimination of the malposition of the fingers in a severe disease stage is always accompanied by the formation of a skin defect with the size determined by the stage of contracture. Currently, one of the demands that patients make is to reduce the duration of the disability. An important condition for fulfilling this requirement is the primary healing of hand wounds, which can be achieved only by plastic replacement of defects that have formed after the elimination of the contracture of fingers. Since all formed defects are deep, i.e., with exposure of the flexors and neurovascular bundles, the only possible way to replace them is plastic surgery with a blood-supplying complex of tissues, the choice of which is determined by the defect size. Nevertheless, Z-plasty remains the most common technique for filling soft tissue deficiency after aponeurectomy. However, its efficiency decreases with the increase in the disease severity. To date, there is no consensus on access to the altered area of the aponeurosis and the choice of methods for filling the tissue deficiency in stages III-IV of the disease.

DISCLAIMERS

Author contribution

All authors made equal contributions to the study and the publication.

All authors have read and approved the final version of the manuscript of the article. All authors agree to bear responsibility for all aspects of the study to ensure proper consideration and resolution of all possible issues related to the correctness and reliability of any part of the work.

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