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# Features of Radiologic Diagnostics in the Determination of Femoral Stump Defects in Primary Prosthetics

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**Abstract:** This work is based on a clinical and laboratory study of 43 patients and persons with disabilities who underwent primary prosthetics of the hip stump. Observations were carried out in the period after surgery from 1 month to 6 months in the period from 2014 to 2019 at the clinic of the National Center for Rehabilitation and Prosthetics of Persons with Disabilities. Post-traumatic amputation of limb segment most often occur in patients of young working age, which determines the great socio-economic significance and relevance of reconstructive operations. After amputation of the limb, the processes of restructuring of the tissues of the stump occur under new conditions of blood circulation. Changes in the circulatory system are associated with narrowing of blood flow and thickening of the walls of large arterial and venous vessels, as well as an increase in the number and caliber of capillaries. The defects of the stump are very diverse, these are short and excessively long stumps, the high location of truncated muscle to the skin scar, etc. Diseases of the stump (osteonecrosis, osteophytes, osteomyelitis, phantom pain, ligature fistulas and long-term non-healing wounds) and the result of technical errors in surgical interventions, wound infection and irrational prosthetics. Based on this, it is advisable to use early Doppler ultrasound and X-ray diagnostics in determining malformations and diseases of the stump in order to carry out primary prosthetics. Express prosthetics of the amputation stump in post-traumatic amputations gives a high rehabilitation effect compared to other pathologies: both vascular and other systemic pathologies. The results of complex studies are presented: clinical (orthopedic, neurological), psychological, X-ray, ultrasound, Doppler ultrasonography.

**Keywords:** Amputation Femoral Stump, Prosthetics, Radiography, Ultrasound Examination, Doppler Ultrasonography

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## 1. Introduction

Prosthetics after amputation of the lower extremities is the most frequent and difficult problem of medical and social rehabilitation of patients with trauma and orthopedic profile [1, 2].

Traumatic amputations of limb segments most often occur in patients of young working age, which determines the great socio-economic significance and urgency of the problems of restorative operations. According to the literature, 50,000 amputations are performed annually in Russia. Of these, 51% - for obliterating diseases of the vessels of the lower extremities, 26.2% - for diabetes mellitus [3, 4]. Hip amputations account for 61.5%, of which paired hip amputations account for 59%.

It is known that after amputations of the lower extremities

in 70% of cases, there is a presence of vicious stumps, including those complicated by pain [5, 6].

The higher the level of amputation, the more difficulties the prosthetist experiences to manufacture a prosthesis in which the patient can move independently or use aids for walking. After amputation of the limb, the processes of restructuring of the stump tissues occur under new conditions of blood circulation. Changes in the circulatory system are associated with narrowing of the lumen and thickening of the walls of large arterial and venous vessels, as well as with an increase in the number and caliber of capillaries. After amputation, topographic and anatomical disorders, pathological restructuring of tissues, defects and diseases of the stump develop, which impede full rehabilitation and significantly aggravate the disability of patients. [7-9].

Defects of the stump are very diverse: they are short and overly long stumps, high location of truncated muscles, bone sawdust, excess soft tissue over it, attachment of muscles to the scar, skin, etc. These changes most often cause disruption of blood supply and tissue trauma during axial load on the stump in the prosthesis, making it impossible to use it.

Diseases of the stump (osteonecrosis, osteophytes, osteomyelitis, phantom pains, ligature fistulas and long-term non-healing wounds) are the result of technical errors in surgical interventions performed, wound infection, irrational prosthetics, etc. Timely and accurate identification of these pathological changes, assessment of the condition of the stumps of the extremities are fundamental points in preparing patients for early primary prosthetics, as well as in monitoring the effectiveness of permanent prosthetics [10-15].

Based on this, it is advisable to use early ultrasound and X-ray diagnostics in the determination of defects and diseases of the stump in order to carry out primary prosthetics.

The aim of the study was to evaluate the effectiveness of various methods of radiological diagnostics in the determination of defects and diseases of the hip stump after amputation.

## 2. Materials and Methods

The studies were carried out on 43 patients from 2014 to 2019 at the clinic of the National Center for Rehabilitation and Prosthetics of Persons with Disabilities (29 men, 14 women), in the period from 1 month to 5 years after the operation. The average age of the surveyed was 49 years. An amputation stump due to trauma was diagnosed in 31 patients, amputation after vascular pathology was diagnosed in 6 patients: vein thrombosis and obliterating endarteritis, and in 6 patients hip amputation was performed due to diabetes mellitus. All patients underwent clinical, orthopedic, neurological, psychological, ultrasound and X-ray examinations over time.

Radiation diagnostics of the condition of the femoral stump included:

- 1) standard radiography with 2x magnification of the image on the DMS/APELEM BACCARA 90/20 apparatus, in standard installations in two mutually perpendicular projections;
- 2) ultrasound examination on the SONOSCAPE S8 apparatus using linear transducers with a frequency of 7.0-15.0 MHz.

Scanning was performed on the anterior and posterior surfaces of the stump in the transverse and longitudinal directions. During the study, the course of the neurovascular bundles was necessarily traced both in the gray-scale mode and with the help of pulse-wave Doppler, energy and color Doppler mapping, and the postoperative scar was assessed with particular care at the polypositional position.

## 3. Results and Outcomes of the Study

Preparation of patients for early primary prosthetics was carried out within 15–20 days after amputation of the hip. Particular attention was paid to the primary wound healing,

the condition of the stitches, swelling of the stump, the reduction or absence of pain, and the condition of the skin. In 43 patients, in order to prepare for primary early prosthetics, we bandaged the stump with an elastic bandage from the end of the stump to the proximal part of the limb 3-4 times a day after hip amputation surgery. To prevent contracture of the hip joint in the operated limb, special physiotherapy exercises for the hip joint were performed 3-4 times a day from the first day after the operation.

In dynamics, we studied the state of the bone tissue of the stump, changes in soft tissue components and the state of blood circulation in the stump before, one month and three months after prosthetics using X-ray and ultrasound (Doppler).

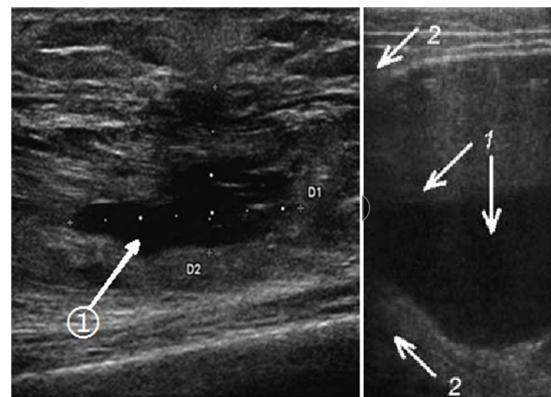
In this preparatory period, our goal was in the early stages to achieve the formation of a functionally advantageous amputation stump, which would have the following characteristics:

- 1) the formation of a cylindrical coronal part with a thickness of the musculocutaneous flap from 1 to 5 cm;
- 2) preservation of the correct axis of the stump bone and the formation of a compact type of endplate at the bone sawdust;
- 3) the absence of the formation of contractures of the adjacent joints of the operated limb;
- 4) absence of muscle atrophy and chronic pain syndrome;
- 5) postoperative scar formation with no signs of inflammation;
- 6) the absence of clinically significant osteophytes, signs of destruction and osteoporosis of the bone.

The study of the formation of the stump by X-ray and Doppler ultrasonography showed the presence of a difference in the dynamics of the formation of the post-traumatic amputation stump and other amputation stumps.

In a Doppler study of a post-traumatic amputation stump, focal changes in soft tissues are determined in the form of a volumetric formation of limited infiltration inflammation (hematoma, seroma, cyst or neuroma). In 1-2 days after amputation, intermuscular and intramuscular hematomas can be visualized by ultrasonography

On echograms, hematomas are seen as low echogenic, oval or round, containing fluids in the form of lesions with even contours (Figure 1).



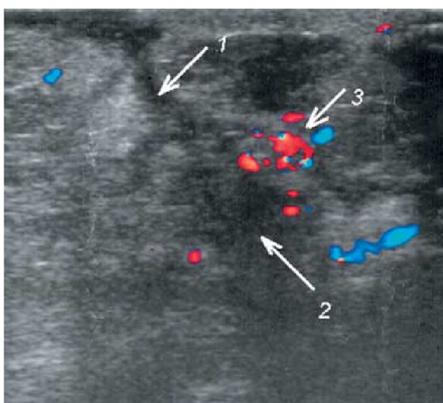
**Figure 1.** Intermuscular hematoma of the quadriceps muscle of the right thigh. Ultrasound examination of the amputation stump of the thigh. Hematoma. 1 - hematoma, 2 - muscle tissue.

Inflammation can slow wound healing and can cause fistulous wounds in amputation stumps. The echogram of the course of the fistulous wound during ultrasound is characterized by a tubular hypoechoic shadow with even and regular contours. On the basis of the fistula, a hypoechoic cavity with uneven contours is determined, inside the cavity with anechoic focusing formations. With Doppler ultrasonography of this area, a local increase in blood circulation is noted.

In 2 patients, the detected hematoma was removed by puncture with local anesthesia. After that, the edema in the stump decreased, pain relief and primary wound healing were observed.

Clinical example:

Patient A, 56 years old. Diagnosis: Gangrene of the right foot. 20.11.2015 Operation: amputation of the right thigh (Figure 2).



**Figure 2.** Ultrasound scan. Inflammatory infiltration (color Doppler mode). 1 - sinus tract, 2 - inflammatory infiltrate with a cavity, 3 - increased blood flow spectrum.

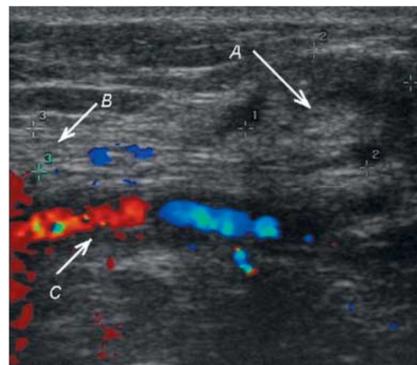
Using color Doppler mapping, blood flow was assessed along the common femoral, deep femoral, and superficial femoral arteries to the ligation site. In all cases, the blood flow in these arteries was of the main type, the linear blood flow velocity in the common femoral and deep femoral arteries was 0.55-0.75 m/s, along the surface of the femoral artery, 0.20-0.65 m/s. In the distal surfaces of the femoral artery, in a number of cases, thrombotic masses, heterogeneous in echogenicity, were projected. In the examined patients, the main veins were patent.

In the stump, with post-traumatic amputations, an increase in collateral circulation is noted. Collateral circulation of the stump is poorly developed in patients with concomitant pathologies such as obliterating endarteritis, diabetic angiopathy, etc.

3 months after prosthetics in the stump, the following picture is noted.

The identification of terminal neuromas was one of the most difficult tasks in assessing the condition of the stump before prosthetics and required a particularly careful standardized approach. Only in 50-65% of cases, neuromas were accompanied by local or phantom pain, which occurred when the crossed end of the nerve fell into a scar, a zone of inflammatory infiltration, or was compressed when using a

prosthesis. Neuromas were diagnosed in 5 cases. On ultrasound, they were visualized along the neurovascular bundle as rounded formations with clear contours, mixed echo structures, ranging in size from 5.0 to 25.0 mm. Palpation of the projection site of the neuroma under the control of an ultrasound probe caused local pain. (Figure 3).



A neuroma; B-stump of the femoral nerve; C-superficial femoral artery;

**Figure 3.** Ultrasound scan. Neuroma (color Doppler mode).

After examining the bone parts of the stumps, an analysis of the state of the soft tissues was carried out. They were assessed both visually and by ultrasound.

Ultrasound examination allows you to reliably determine:

- 1) structural changes in the skin, subcutaneous fat, muscle tissue (atrophy, fatty, fibrous or combined degeneration, inflammatory changes with or without fistula, traumatic focal pathology - hematomas, seromas, pseudocysts, neuromas);
- 2) the contours of the tissues (even, uneven) and their thickness (thinning or thickening);
- 3) the state of the postoperative scar (size, contour, position, pathological changes);
- 4) the presence of foreign bodies;
- 5) changes in blood flow (thrombophlebitis of the great saphenous vein in 4.6% of patients, stenosis of arteries in the proximal parts of the amputated limb - in 46.5% and at the site of ligation - in 69.7% of patients).



**Figure 4.** Amputation stump of the right thigh of patient K., 56 years old (8 weeks after amputation). Standard radiography with direct 2x magnification.

1. Transverse osteophyte. 2. Cystoidal reconstruction of the amputation edge of the stump. 3. Endplates.

When conducting a standard X-ray of the cult, the following picture was determined (Figures 4 and 5): a change in the shape of the distal sections of the bone stump and sawdust, which were due to the peculiarities of the formation of the endplate, as well as the severity of periosteal reactions that arose under the influence of various factors (infection or aseptic conditions) and in most cases were a source of osteochondral growths - osteophytes. Their characteristics were carried out depending on the features of the structure, the localization of the base and the direction of growth. According to the localization of the base, axial (endosteal), borderline and paraosseal osteophytes were distinguished. According to the direction of growth, osteophytes were subdivided into cranial, caudal, and transverse.



**Figure 5.** Amputation stump of the middle third of the right thigh.

Patient K., 56 years old (after early primary prosthetics). Front and back views

It should be noted that osteophytes in a number of cases were a diagnostic finding and did not manifest themselves in any way clinically. Their shape and size did not significantly affect the support ability of the stump. Axial caudal osteophytes were of clinical importance, since they could cause inflammatory changes in the underlying tissues and severe pain when using the prosthesis.

Degenerative processes accompanied by a decrease in bone mass (osteoporosis, atrophy, cystic remodeling) began to be observed at 4–5 weeks after limb truncation. During these periods, osteoporosis was found in 70.0% of patients with a femoral stump. The most reliably structural rearrangement was revealed by standard radiography.

With the limitation of the function of the femur stump due to defects or diseases, structural changes in the bone occurred, which, with long-term existence, inevitably led to its atrophy. The bone stump became thinner, from cylindrical to conical.

With permanent prosthetics, atrophy, as a rule, concerned only the distal stump. In the absence of prosthetics, the atrophy was more expressed, the end of the truncated bone became sharply conical, pointed.

During standard X-ray examination, 5 patients were found to have defective, excessively long femoral stumps (up to the

level of the lower third of the thigh), which required further re-amputation.

In 3 patients, excessively short femoral stumps were obtained, into which prosthetics were significantly difficult. In 11 patients, there was a vicious condition of the stumps, with redundancy or insufficiency of soft tissues in the coronal part of the stumps, as a result of which the stumps had a sharply conical or clavate shape. In 6 patients with excess or insufficiency of soft tissues, we performed stump reconstruction operations to create a normal prosthetic stump.

Thus, in the skeleton of the stump, processes were simultaneously taking place that combined a complex of reparative and degenerative changes, the severity of which was due to the degree of compensation for the function of the truncated limb and the complications that arose.

Significant functional and structural disorders were observed in 18.6% of patients with femoral stumps with osteomyelitis, which complicated wound healing after amputation. They developed against the background of tissue damage caused by direct trauma, thrombosis and vascular embolism, as well as a result of technical errors in the performance of surgical interventions. Aseptic osteonecrosis appeared only at the end of the truncated bone. More often, insignificant areas of the saw contact zone were necrotic, less often, most of it. With aseptic osteonecrosis, lacunar bone resorption occurred without suppuration.

Against the background of atrophy and osteoporosis, 3 months after amputation, in 60.0% of cases, cystic restructuring was observed, which was noted not only near the saw cut line, but also in more proximal parts. Over time, this process gradually progressed, reaching its maximum development by 5–6 months after amputation. During these periods, in 75.0% of the victims, cystic restructuring in amputation stumps was combined with osteoporosis in 97.1% of cases, and with bone atrophy in 65.7%.

Comprehensive clinical and radiation examination of patients within 15–20 days after amputation of the hip for early primary prosthetics showed positive cases in 67.5% of patients. The remaining 32.5% of patients had defects or diseases of the hip stump that arose under the influence of external or internal factors caused by surgery or an associated wound infection. Radiation examination allows us to reliably identify defects and diseases of the hip stump.

## 4. Conclusions

1. Early ultrasound scan with Doppler sonography and standard radiography make it possible to diagnose the condition of the soft tissues and vessels of the amputation stump, as well as bones, which play an important role in express prosthetics.
2. Early diagnosis with the identification of complications such as neuromas, fistulas, pseudocysts, osteophytes, the presence of foreign bodies, etc. in the amputation stump, enable doctors and prosthetists to determine the correct approach to prosthetics with the elimination of problems.

3. Express prosthetics of an amputation stump in post-traumatic amputations gives a high rehabilitation effect, in comparison with other pathologies: such as vascular and other systemic pathologies.

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