

## **Methods of determining the amputation level of lower extremity**

**Bülent Kılıç<sup>1</sup>, Ali Serdar Yücel<sup>2\*</sup>, Çetin Yaman<sup>3</sup>, Gülten Hergüner<sup>3</sup> and Murat Korkmaz<sup>4</sup>**

<sup>1</sup>*Orthopedist, Cengiz Topel Meydanı. Şabanoğlu Sok. No: 5, Tekirdağ, Turkey*

<sup>2</sup>*Fırat University School of Physical Education and Sports, Elazığ, Turkey*

<sup>3</sup>*Sakarya University School of Physical Education and Sports, Sakarya, Turkey*

<sup>4</sup>*Güven Group Inc, İstanbul, Turkey*

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### **ABSTRACT**

*Our purpose in this study is to share our experiences and results regarding the determination of amputation level of lower extremity. A total of 21 patients were included in our study, below-knee amputation was applied to 12 patients for diabetic reasons and 9 patients with traumatic reasons. Various methods were used to determine the level. No post-operative complications occurred apart from subcutaneous hematoma, wound detachment and sterile temporary discharge in all patients. Amputation is the surgical removal of a damaged extremity that cannot be repaired together with its bone from the body. The purpose of amputation is to remove infected, injured or non-functional extremity in post-reconstruction, to bring the patient's function to a sufficient level, to protect length and strength of extremity, to maintain balance between the muscles left for a stable extremity, to provide maximum independent free motion, to remove diseased tissue, to reduce morbidity and mortality, to minimize complications, to ensure wound healing and balance of sitting, and to make position and transfers easier. With this purpose, it is highly important to determine the level of amputation correctly. In the study, the reasons and types of amputation in lower extremity and methods of determining level have been expressed.*

**Keywords:** Method, Amputations of Extremity, Vascular Embolization

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### **INTRODUCTION**

Amputations of extremity are one of the oldest surgeries [1, 2]. Amputation is the surgical removal of a damaged extremity that cannot be repaired together with its bone from the body [3]. Amputation is the procedure of cutting the extremity in a way to include its distal [4]. It is applied when the extremity is thought to be impossible to be recovered following a serious injury, in case of tissue loss depending on vascular embolization disorders and in the presence of uncontrolled infection [5, 6].

The amputation of an extremity that is not alive functionally can be the first step to make it re-function. Attempts to recover an extremity that has lost its function and is on the edge of liveliness result in deterioration of patient's general condition and losing the chance of ambulation. The purpose is to increase the patient's function and quality of life [7-9]. Injuries with high energy are among the mostly seen reasons for lower extremity injuries. Amputations of lower extremity are permanent defects limiting the individual's activities, requiring handling with many social and psychological conditions, reducing the quality of life in terms of health and requiring a miscellaneous life-long compatibility process [10-12]. The process passing from the surgical treatment of lower extremity injuries to their rehabilitation requires a multidisciplinary approach concerning many specialists, particularly orthopedics and traumatology [13]. In all major lower extremity traumas with fractures, tissue loss, nerve and vein injury, the

surgeon has to decide between amputation and recovery surgery in a short time. Extremity must be medically evaluated while deciding on amputation, and possible post-operative complications, recovery period, possible changes in patient's daily activities and quality of life following the anatomic and functional loss should be foreseen [13]. In this study, the amputation procedure applied to the damaged lower extremities with such reasons as trauma, diabetic neurovascular reasons, peripheral vascular diseases, infections, injuries, tumors etc. will be explained [13].

### **Anatomy of Lower Extremity**

We can examine the anatomy of lower extremity as distal femur, proximal tibia, joint space, popliteal fossa and soft tissues around the joint [14]. Both distal femur and proximal tibia contain plenty of spongiosis bones. Surrounding of articular surfaces at the ends is limited to thin subchondral bone with no vascular transition. There is a thick articular cartilage above this. Femur and tibia metaphysis are encircled with the recesses of joint capsule out of the posterior region. Joint capsule has a significantly dense network of collagen. Although synovial layer covering the inner surface of capsule has multi-vascular structure, there are no trans-capsular vascular connections extending from synovia to periarticular soft tissue. Veins without valvula in intermediary layer of capsule extend from tibial epiphysis to femoral epiphysis. While popliteal fossa has a good limit with gastrocnemius fascia of joint posterior capsule and tendinous insertions of hamstrings on the front; popliteal artery and sciatic nerve branches are across this region at the back and they constitute nearly a boulevard for upper and lower extension of tumoral lesions [14].

### **Etiology**

Irreparable injury in the circulation of injured or damaged extremity is the only indication of amputation. If an extremity can't be fed, it becomes a useless organ for body and poses danger because of toxic substances which give off in time. In some cases, uncontrollable infection of extremity becomes a life-threatening issue and amputation is the only solution [1, 2, 4, 15]. We can sort the reasons for amputation of lower extremity as; 1-Peripheral vascular diseases, 2-Diabetes mellitus, 3-Trauma, 4-Infections, 5-Tumors, 6-Nerve injuries, 7-Congenital abnormalities [13].

*1- Peripheral Vascular Diseases:* Among all reasons for amputation of lower extremity, it comes first [13, 16, 17]. Those patients are generally aged over 60 [1, 18]. Buerger's disease and Raynaud's phenomenon are among the peripheral vascular disease group. Atherosclerosis Obliterans is a chronic artery disease in degenerative type. It is characterized by narrowing, lengthening and embolization of small and medium-sized arterioles. Reynaud's Phenomenon is a chronic disorder frequently progressing with the ischemia symptoms on upper extremity fingers episodically and not leading to narrowing in lumen [1, 15].

*2-Injuries (Trauma):* Trauma comes second among the etiological reasons (25%) and it peaks between the ages of 17 and 55 [1, 13, 19]. The mostly seen reasons of traumatic amputation are firearm injuries, traffic accidents, occupational accidents and sharp object injuries [6, 7, 19]. Thermal burns, freezing and electric shocks are generally the reasons for amputation of lower extremity [1, 6, 15].

*3-Diabetes Mellitus:* Diabetes is an endocrine disease progressing with the relative deficiency of insulin or non-response of end organs. Diabetes-dependent amputations of lower extremity have a high post-operative mortality and require high level of secondary surgery [1, 5, 6, 15, 20-23].

*4-Infection:* Acute or chronic infections with no response to medical or surgical treatment are relative indications for amputation. However, fulminant gas gangrene progresses much faster than other infectious factors and patient's life can be saved with the amputation that is carried out by leaving open stump with more proximal from living tissues [1, 2]. The most frequently seen factor in infections is anaerobic and mixed infections that generally develop on the basis of diabetes [24]. A carcinoma may rarely develop from an infected chronic sinus, and this can be an indication for amputation [1].

*5-Tumors:* Benign tumors don't general require amputation. Amputation is a treatment option preferred in malign tumors that do not have metastatic spread [1, 2]. Ignored tumors, tumors progressing under the induction treatment (chemotherapy, radiotherapy) and treatment complications are the real indications of amputation today. Big vascular-nerve invasions that were thought as the reason for amputation in the past have become relative amputation indications today. Vascular-nerve reconstruction, free tissue transfers, earlier diagnosis and treatment of tumors reduce the need for amputation [14].

*6-Nerve Injuries:* If the extremity has started to be an ulcer depending on the nerve injury and if infection and tissue loss can't be controlled with other treatment methods, it becomes indicated [1, 2, 6, 14].

*7- Congenital abnormalities:* Amputation of an extremity with congenital defect may be required for a good prosthetic alignment [1-3].

### **Amputation Types of Lower Extremity**

Disarticulation means performing amputation at joint level [25]. Amputation types of lower extremity by the levels are below:

- a. *Metatarsophalangeal disarticulation*; it is generally the amputation of metatarsus heads near the proximal.
- b. *Lisfranc amputation*; it is the tarso-metatarsal disarticulation.
- c. *Chopart amputation*; it is the disarticulation through talonavicular and calcaneocuboid joints in midtarsal joint.
- d. *Syme's amputation*; it is the transmalleolar amputation. Malleolar parts of tibia and fibula are sawed off, and closed with subcutaneous tissue and heel skin. Such amputations are not cosmetically appealing as the prosthesis used is insufficient to adjust to the shape of leg.
- e. *Boyd amputation*; It is the removal of all tarsals except calcaneus.
- f. *Below-knee amputation*; it is generally practiced from 1/3 upper and medium joint of tibia. Fibula is cut slightly shorter than tibia and a cylindrical residual extremity is created [22, 23]. As different from Syme's amputation, distal of tibia isn't given weight [22].
- g. *Above-knee amputation*; it is practiced at 1/3 lower, medium and upper levels of femur.
- h. *Hip disarticulation*; it is the disarticulation practiced from the coxofemoral joint.
- i. *Hemipelvectomy*; it is the disarticulation practiced from sacroiliac joint.
- j. *Hemicorporectomy*; it is the amputation of lower half of the body [13, 25].

## **MATERIALS AND METHODS**

### **Determining Amputation Level**

It is highly important to determine the amputation level correctly.

Mangled Extremity Severity Score (MESS) contains a scoring system according to the patient's status, age, type of injury and ischemia status of extremity. 7 points and above indicate nonrecovery of extremity, and 7 points and below indicate that it is possible to save the extremity. Amputation is carried out for the cases with 7 points and above [1].

Laboratory criteria are clinically utilized in determining the amputation level. Arterial angiography, Doppler USG, perfusion pressures on segments and pulse volume and arteriography records can be counted among them. Measurements of cutaneous oxygen pressure and Radionuclide Xenon isotopes are used as further and expensive researches in determining healing [7, 8, 15, 26].

- Arteriography: It can be used for the diagnosis of vascular diseases. Segmental blood pressure is one of the most widely used methods. It is based on the presence of systolic pressure with the fully measured cuff. Additionally, superficial artery doppler signal and photoplethysmography are used [15].
- Blood pressure of skin: This method was developed because of the difficulties in measuring segmenter systolic pressure [15, 27-29].
- Measuring the blood flow of skin with xenon: Blood flow exists [15].
- Transcutaneous oxygen pressure: Metabolic potential and heat capacity of the tissue are measured [15, 30].
- Radioactive micro corpuscles: have been stated to demonstrate blood flow of injection intra-arterially [15, 31].
- Doppler ultrasonic flowmetry: It is used to measure highly embolic veins.
- Electromagnetic flowmetry: In principle, it is based on the anti-magnetic field created by moving blood and measurement of electric potential which occurs vertically to blood flow.
- Thermistor-thermometry and liquid crystal thermography: It is based on the observation of heat of skin surface.

The rates of heat changes in the whole body to the room and forehead temperatures are examined [15, 32].

As a general principle, albumin level of the patient who will go through amputation should be above 3gr/dl, total protein above 6g/dl and total lymphocyte above 1500 [33]. The level of amputation must separate the diseased part from the extremity and allow tissues heal [2]. Short amputation stump complicates prosthesis adjustment and causes a walking pattern with more exertion [34]. In patients with such short-type amputation stump, 6-8 cm of extension in femur is possible with external fixators recently [1, 35].

The level of amputation may change depending on the etiological reasons. Among the amputation types of lower extremity, the most preferred one is generally below-knee amputations depending on the status of extremity and type of injury. Partial foot amputations come next [13].

Amputation must be performed over the injured tissue level and from the level as distal as possible by taking into account the presence of soft tissue required for appropriate stump, the possibility of pain and senseless area,

inclination to infection, personal situation, the effect of level on functional loss and prosthesis. The closer the weight bearing region is to the ground in amputations of lower extremity, the better balance is maintained, and functional capacity obtained with the prosthesis reduces and the energy consumed increases if the level increases. The level of amputation should be determined in a way to obtain a successful healing and maximum function in post-operative period. As preferring an inappropriate level may cause a secondary surgery in patients, the pre-operative evaluation is highly important [13]. Amputation in cases of trauma should be determined by considering the status of bone, vein, nerve and residual muscle [35]. Determining the level can be difficult in patients with vascular problems, particularly [13, 36, 37] transcutaneous.

While determining the level of amputation, 1-Physical factors 2-Co-existing diseases 3-Experience and skills of surgeon 4- Nutritional status of patient are taken into account [1].

- Physical factors: Tissue necrosis or infection, transcutaneous oxygen level and circulation level of extremity [1].
- Co-existing diseases: Diabetes, peripheral vascular diseases or existence of other systemic infections [1].
- But the most frequently used method is the decision of surgeon during the surgery [1, 38].

## RESULTS

21 patients with the below-knee amputation performed between 2005 and 2012 were included in our study. 12 of our patients were amputated due to diabetic reasons and 9 of them for traumatic reasons. Direct graphy, Doppler usg, arteriography and laboratory examination were performed in all patients. Microbiological examination of wound site and MR examination were carried out in diabetic patients. Bone infection wasn't observed in diabetic patients, only soft tissue infection was found. Total amputation was performed in all patients at different levels of below-knee under general or epidural anesthesia following the necessary preparation. In traumatic cases; amputation was performed on the region appropriate for the pre-determined level for those with segmental fracture and arteriographically diagnosed with circulatory disorder at the same level due to the fact that distal tissue has completely lost its characteristics. In diabetic patients; as macroscopic blood flow was observed to be sufficient in 1-3 cm proximal to the clinically and arteriographically determined level, amputation was performed at those levels. Follow-up was carried out on all patients in polyclinic following the hospitalization for post-operative wound care. Subcutaneous hematoma was seen in 3 patients on whom traumatic amputation was performed, detachment of wound site was seen in 4 diabetic patients and serous discharge from wound site was seen in 5 patients and healing was ensured with dressing. On long follow up, 1 of our patients, we see reactive bone formation of distal fibula, this patient complained small pain on high loading to leg at distal of amputated leg. Following the wound healing and tissue compatibility, all our patients were ensured to walk with prosthetic legs in the 4th month of post-operative period approximately.

## DISCUSSION

Amputation of lower extremity is a permanent incompetence which limits activities and participation and causes a decrease in quality of life about health [12, 39]. Amputations are still performed in orthopedic surgery frequently. The purpose of amputation is to remove infected, injured or non-functional extremity in post-reconstruction, to bring the patient's function to a sufficient level, to protect length and strength of extremity, to maintain balance between the muscles left for a stable extremity, to provide maximum independent free motion, to remove diseased tissue, to reduce morbidity and mortality, to minimize complications and to ensure wound healing and balance of sitting, and to make position and transfers easier [1]. As seen in our long follow up of the patients, 1 of our patient amputated end of fibula formed reactive bone and this gived small pain to the patient. It can be because of amputation level. With this purpose, it is highly important to determine the level of amputation correctly. The biggest problem after deciding amputation is deciding on level, post-operative treatment required for maximum function and choosing the prosthesis. Clinical levels of ischemia and laboratory criteria are used in deciding the level of amputation [7].

Limitations of our study are amputations done just by 2 reasons (diabetic and traumatic), done by small number of patients, all surgeries are done by same surgeon. We need other studies done by bigger number of patients, by many different surgeon, done because of many different reasons.

Amputation effects person's psychology, health, mobility etc lifelongly, so it is very important surgery. Because of development of new diagnostic and treatment techniques, we need many new publications done in this field.

## CONCLUSION

An amputation of lower extremity is a type of surgery which is needed to be performed today for various reasons and can sometimes be lifesaving. The most important criterion is circulatory disorder. Aside from the various examinations, the experience of surgeon is the most important factor in deciding the amputation level.

We utilize various radiological and invasive methods in deciding the amputation levels of lower extremity. However, the reason for circulatory disorder is of vital importance as can be seen in our study. No matter what the level we have determined in diabetic patients with Doppler or venography is, the level may change depending on the blood situation of the tissue determined by the surgeon during the operation etc.

Due to the fact that we have diabetic and traumatic patients in our study with a limited number and one surgeon, it will be useful for the studies that were carried out about amputations for different reasons with high number of patients and many surgeons. Amputation is a type of surgery which bears a life-long importance for the person's psychology, health, function etc. As seen with one of our patients, amputation level also important in long time, we see reactive bone formation at the end of amputated leg may be wrong amputation level. As current methods of diagnosis are continuously improving, there is a constant need for new publications in this field.

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**Adds:****1) Example 1:**

The patient who's left leg was amputated in our clinic because of an accidental trauma, at the below knee level. After 2 years using leg prosthesis, the patient feeled pain at the distal point of leg during loading. We diagnosed fibular reactive bone formation and followed.

**2) Example 2:**

The patient's right knee was amputated in our clinic because of diabetic circulation problem and infections.

