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Critical Appraisal of Foot and Ankle Amputations in Diabetes

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Abstract

Diabetes is the leading cause of non-traumatic amputation in the world. Patients with diabetes have a 10-fold increased risk for lower extremity amputation compared with those who do not have diabetes. Amputees with diabetes are more likely to be severely disabled, to experience their initial amputation at a younger age, progress to higher-level amputations, and die at a younger age compared with patients without diabetes. Indications for amputation are chronic lower limb ulcers, infected or not infected, due to peripheral neuropathy, vascular disease or deformity of the feet. Foot ulcer precedes amputations in 84% of the cases.

Amputation in diabetes is not a riskless treatment. The 5-year relative mortality rate is 48% after major limb loss. After a major limb loss, there is a 50% probability of developing a serious lesion on the contralateral limb within 2 years.

In the present review and clinical appraisal, indications for determination of the level of amputation, the possible consequences of a specific amputation on stance, deambulation, necessity of using a specific footwear or prosthesis, technical problems and complications are discussed.

Introduction

Diabetes is the leading cause of non-traumatic amputation in the world [1]. The overall risk for amputation is increased in diabetes 15-fold beyond that for nondiabetic people. In the United States, the annual incidence of lower extremity amputation in those with diabetes is 5–8 per 1,000 [2,3]. Foot ulcer precedes amputations in 84% of the cases [4]. Up to 25% of those with diabetes will develop a foot ulcer over their lifetime [5,6].

More than half of those ulcers will become infected, and 20% will necessitate an amputation [7]. Approximately 60% of the limbs that are amputated are complicated by infection [8]. It is important to remember that amputation is not a riskless treatment. The 5-year relative mortality rate is 48% after major limb loss. After a major limb loss, there is a 50% probability of developing a serious lesion on the contralateral limb within 2 years [6].

A patient with diabetes and comorbidities may not have sufficient cardiophysiologic reserves to ambulate effectively after proximal amputation, resulting in sedentariness and cardiovascular deconditioning [6]. Given these grave physical, psychological, and financial costs, every effort should be made to avoid a limb loss situation. Effective preventive care can help to avoid ulcers and infections, the common prequels to amputation. When the limb is at risk, specialized care involving a multidisciplinary team approach and organized care can reduce the rate of amputations [6,9-11].

The aim of the present paper is to review the literature about the indication and the results of foot and ankle amputations in diabetic patients.

Determination of Amputation Level

A plethora of tests have been promulgated in the surgical and orthopaedic literature as the “best” method to determine the proper level of amputation [12]. These procedures include arterial Doppler pressure measurements, fluorescein angiography, transcutaneous oxygen tension measurements, and xenon clearance [7,13-15].

The most generally used and largely available test is the arterial Doppler ultrasound. This is most useful as a guideline to general levels of perfusion and is the best initial screening test to determine whether the patient needs a vascular surgery consultation and an arteriogram [16]. Some authors advocate transcutaneous oxygen measurements. These measurements are clearly much more cumbersome to perform than Doppler studies [17].

Toe Amputations

Digital amputations are the most common amputations performed in the foot.

The amputation of a toe leaves no significant disability in stance or gait, although it must be remembered that:

Amputation of the great toe, though not due to important instability in stance, greatly reduces the thrust force during the gait, where the hallux with the flexor hallucis longus and flexor brevis play a fundamental role, with possible metatarsalgia of the 2nd and 3rd rays [18]. Murdoch et al. [19] educed data from 90 diabetic patients who underwent hallux and first-ray amputations over a 10-year period. The researchers found that 60% of the patients required a second amputation at a mean 10 months after surgery. Twenty-one patients went on to a third amputation, while 7% required a fourth. Seventeen percent of the patients had a subsequent below-knee amputation (BKA) and 11% had a transmetatarsal amputation (TMA) in the same extremity, whereas 3% had a BKA and 2% a TMA on the contralateral side. Borkosky et al. [20] in a systematic review, including a total of five studies of 435 patients, reported a high incidence of 19.8% of re-amputation. The same authors, in an 11-year retrospective review of 59 patients with partial first ray amputation, reported an incidence of 42.5% (25 patients) of more proximal amputation, with a mortality rate of 47.5% [21]. From the results of their study, the authors concluded that a large proportion of patients receiving an amputation at the level of the great-toe or first-ray receive higher-level amputations in the first year following initial amputation, so this type of amputation should be avoided [6].

The amputation of a central toe (2^{nd}, 3^{rd} or 4^{th}) causes forefoot instability, not only because of the digitigrade contribution during the gait, but especially because it can cause deformities of the adjacent toes. For example, the space created after the amputation of the 2^{nd} and/or 3^{rd} toe, can create or worse a hallux valgus [12].

The isolated amputation of the fourth toe, leaving in place the fifth, can cause traumas and sub-dislocations of the latter [22].

Ray Amputations

Amputation of a single ray

Amputation of the first ray causes, in addition to a deficiency in the boost phase of the step and the loss of plantar-flexion of the toe, a collapse of the medial column with a possible evolution towards a pronated and valgus foot. Moreover, ulcerative lesions or stress fractures of the other rays [22].

It is important to keep the insertion of the anterior tibial tendon and peroneus longus tendon on the metatarsus, leaving a functionally valid foot, if necessary with the use of an orthotic prosthesis.

The amputation of a central ray is functionally more effective because it only slightly reduces the latero-medial diameter of the forefoot, without biomechanical deficits [23,24].

The amputation of the fifth ray can cause, if it has been sacrified the basis of the fifth metatarsal, where there are the insertions of the peroneus brevis and peroneus third, a varus, adducted and supinated foot, because of the prevalence of the posterior tibial tendon, with possible ulcerative lesions or stress fractures [25].

Amputation of two rays

The amputation of the first two rays amplifies the problems caused by the amputation of the first isolated, increasing the probability of ulceration due to the overload on the lateral columns, creating difficulty in wearing a prosthesis. The risk of a subsequent more proximal amputation becomes higher.

Amputations of the last two rays: in this case there is the risk of developing an adduct, varus and supinated foot, but the distribution of the load is more balanced, because of the preservation of the 1^{st}, 2^{nd} and 3^{rd} ray, increasing the possibility of using orthoses, reducing the risk of ulceration and a subsequent more proximal amputation [22]. The amputation of two central rays creates a foot reduced in its latero-medial diameter, but functionally valid and biomechanically balanced.

Midfoot Amputations

Transmetatarsal amputation

McKittrick et al. described for the first time a series of diabetic patients with this kind of amputation [26]. Transmetatarsal amputation (TMA) is typically performed in patients with chronic osteomyelitis involving the forefoot, gangrene of the toes, or a non-healing ulceration with a previously resected first-ray. As mentioned earlier, a first-ray resection alters normal gait characteristics and patients are at higher risk for developing transfer lesions, putting them at risk for subsequent amputation [27-29]. The resection of multiple central rays results in a nonfunctional foot and a TMA is indicated to prevent multiple amputations [12,30].

The amputation must be made at the basis of all the five metatarsals, leaving intact the areas of attachments of tibialis anterior and peroneus brevis on the first and fifth metatarsals, respectively, in order to antagonize the triceps surae and Achilles tendon and avoid an equinus foot. For this purpose, it may be useful the lengthening of the Achilles tendon and a posterior capsulotomy of the ankle and sub-talar joint. Altered biomechanics may require tendon transfers to address the forefoot varus and at times, a split tibialis anterior tendon transfer or a peroneus brevis tendon transfer may be used [31]. Roukis et al. [32] described a flexor hallucis longus and extensor digitorum longus tendon transfer for balancing the foot following a TMA [6]. When appriopriately balanced, the TMA can provide a functional foot. The peroneus brevis to peroneus longus transfer can maintain a plantigrade foot [33]. Schweinberger and Roukis also employ intramedullary screw fixation across the medial and occasionally lateral column to stabilize and balance the TMA in the dysvascular patient. This technique avoids additional incisions that are required for tendon transfers [6,34]. Although common complications are possible, this kind of amputation is one of the most widely performed surgical procedures, thanks to its excellent functional results, ease of finding specific orthoses and prosthesis.

Mueller et al. [35] analized the outcomes of 120 TMA performed on 107 patients over a 4-year period at a single institution. The Authors noticed that 27% of patients developed skin failure, and 28% required a more proximal amputation. Most of the complications occurred within the first 3 months after the amputation.

During the first three months after surgery, the patients begin to ambulate and may inadvertently injure their foot. The authors recommend a rehabilitation program emphasizing protection of the residual foot for at least 3 months to avoid complications [6].

Patients are placed in a compressive type medication with a posterior splint and walking is allowed only with crutches without weight-bearing.

However, patients may however require the use of an ankle and foot orthosis, with a forefoot filler. The brace may be worn in extra-depth shoes.

Lisfranc amputation

A TMA is preferred in deformed, nonfunctional partial forefoot amputation. However, when the infection extends proximally, disarticulation at the tarsometatarsal joint (Lisfranc joint) is necessary [36]. A Lisfranc disarticulation should be considered when there is inadequate soft tissue coverage for a TMA. Compared to a TMA, this more proximal amputation will result in a more pronounced muscle imbalance and deformity [6,22].

Postoperative management is similar to that described for the TMA and, initially, is concentrated on protecting the residual foot and later may require the use of an ankle foot orthosis [12]. Lisfranc amputation mandates tendon balancing and has the same requirements as a Chopart amputation for bracing. Only benefit is if the residual foot is fed predominantly by an anterior tibial or peroneal artery, the Lisfranc preserves the communication with the plantar arterial system through the first perforating branch compared with a Chopart that by nature of the procedure removes this arterial communication.

Chopart's amputation

The Chopart's amputation is a disarticulation through the midtarsal joint, leaving only the talus and calcaneus. Patients requiring a Chopart's amputation often present with infection extending proximally to the midfoot [6,37].

Compared to below-knee or Syme's amputations, it has some advantages: it is possible to use a shoe with a specific filler, avoiding a leg prosthesis, as for the other two amputations, it does not cause limb shortening. A bearing surface formed by the distal talus and the calcaneus is possible, and a skin cover at the calcaneus is present for a good stance [6,12,22]. Schade et al. [38] undertook a systematic review of eletronical databases to identify material relating to the factors associated with a successful Chopart amputation in ambulatory patients with diabetes: the review of the included studies (four studies involving 74 patients) support that a residual functional limb can be maintained for 12 months with the use of a properly fitting high profile prosthetic device for lifelong ambulation.

The early postoperative care of the more proximal foot-sparing amputations focuses on protecting the residual foot. Patients are non-weight-bearing. Generally, after allowing for soft tissue healing, patients are transitioned to a removable cast walker. The need for bracing is the same as the need for a prosthesis with a below-knee amputation. Long-term management and choice of prosthetic will depend on the activity level of the patient [39].

Hindfoot Amputations

Syme's amputation

It is a disarticulation of the ankle joint, invented in the pre-antibiotics and pre-anesthesia era. Its advantage is the reduction of the mortality rate in comparison with the below-knee amputations (25% to 50%) [12].

This amputation preserves function of the knee with a long stump and independence by allowing patients to expend less energy walking than patients with higher-level amputations. The original technique included disarticulation of the foot at the ankle joint with resection of the malleolar projections [6].

Generally, patients are transitioned to a walking cast after 3 weeks and are fitted for a custom prosthetic when all wounds are healed and edema is controlled [40].

Yu et al. [41] reported the results of Syme's amputation in 10 patients. Nine patients were able to ambulate in a prosthesis 4–6 months after surgery. Pinzur et al. [42] performed a retrospective review of 97 patients and reported that 82 patients (84.5%) healed.

It is absolutely contraindicated in patients with deficiency of plantar heel skin integrity. Major complications are due to errors of skin coverage, which is often insufficient and muscle imbalance between the triceps and extensors, with the development of new equinus contractures and evolution in ulcerations and osteomyelitis, requiring higher amputations.

Partial calcanectomy

A partial calcanectomy is an alternative to below-knee amputation for calcaneal osteomyelitis with overlying tissue loss. Originally described by Gaenslen in 1931, this procedure is an excellent option for limb salvage with success rates approaching 70–80% [43,44]. Excellent results have been reported with strict adherence to preoperative criteria and thorough follow-up treatment with appropriate accommodative foot wear [12,45]. Once healed, most patients maintain ambulation and improved quality of life is achieved by preserving a functional limb. Patients are generally kept non-weight-bearing for a period of 6 weeks and then fitted for accommodative footwear. Smith et al. [46] reported an 83% healing rate with partial calcanectomies used for the treatment of large heel ulcers and calcaneal osteomyelitis. Gait mechanics long term are an issue. Maintaining as much of the distal limb is ideal for long-term gait [6]. In cases of forefoot and midfoot pathology necessitating amputation, the calcaneus is maintained after removing the talus, and fused to the distal tibia. This gives stability and maintains some length to the remaining limb, preserves the distal flap and plantar fat pad [47].

Final Considerations

The significant increase in the percentage of minor amputations, reduced the number of major ones, above and below the knee, with a evident increase in the length and quality of life of patients, since a major amputation, results in a percentage of over 50% complications of the contralateral foot in the following 3-5 years and a mortality of about 68% after 5 years [48,49].

The indication to the minor amputations arises when the presence of a neuropathy and ischaemia involves not controllable ulcerations, osteomyelitis and infections. The reflection is on the timing of the intervention and the exact level of amputation, with the aim of obtaining the maximum chance of healing, with a foot morphologically plantigrade, preserving the function, the possibility of prosthesis and the use of footwear as possible normal.

Based on our experience we can assert that the amputation of a single ray leaves no disability important, especially if it concerns to the central ones, with more problems as regards the first, for the deficit in the stance phase of the step, and the fifth, with possible outcomes in a supinated foot, for the deficit of peroneus brevis. For amputations of more rays, the problems of choice of the level are greater. The problem is if it is functionally more effective trans-metatarsal amputation rather than amputation of more rays. Also according to our experience, the healing time shorter, the duration of the correction, the possibility of prosthesis and therefore the use of footwear, make us prefer the trans-metatarsal amputations.

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