J Orthop Spine Trauma. 2022 March; 8(1): 23-6. DOI: http://dx.doi.org/10.18502/jost.v8i1.9061

Educational Corner

Factors That Affect the Level of Lower Limbs Amputation in Diabetic Foot: Educational Corner

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Received: 24 September 2021; **Revised:** 19 December 2021; **Accepted:** 01 February 2022

Keywords: Diabetic Foot; Amputation; Food

Citation: Ghiasi Nezhad S, Moharrami A, Hoseini Zare N, Moazen Jamshidi MM, Mafi AR, Mortazavi SMJ. **Factors That Affect the Level of Lower Limbs Amputation in Diabetic Foot: Educational Corner.** *J Orthop Spine Trauma* 2022; 8(1): 23-6.

Background

Diabetic foot is a major complication of diabetes mellitus (DM) that affect the patients' socioeconomic function. One of the most common complications of DM is ulceration on the foot, which is defined as a diabetic foot disease due to neuropathy and/or peripheral vascular disease on the lower limb. 4-10% of patients with DM have diabetic foot, however, this rate is higher in older patients with DM. In the other hand, 5% of patients with DM have a history of ulceration in their foot, and this rate increases to 15% with aging (1-3).

Diabetic foot heals in most patients (60-80%), but ulceration does not heal in some patients (10-15%), and finally, 5-24% of them will need for limb amputation after 6-18 months from the emergence of the first ulcer. There are two types of diabetic foot ulceration: neuropathic and neuroischemic. The neuroischemic type needs long time for healing, however the neuropathic type heals over a period of 20 weeks (4).

40-70% of patients with neuroischemic amputation of the lower limb have DM (5). Additionally, recent studies recognized that 85% of amputations occurred following diabetic foot ulceration (5). DM-related lower extremity conditions that increase the risk for amputation among people with DM include peripheral neuropathy, peripheral vascular disease, and infections (6).

Loss of sensation that can occur following peripheral neuropathy due to DM might lead to misperception of the foot deformity, pain, and other problems. This condition may cause point pressure on the foot and ulceration. Infections and inadequate blood supply lead to osteomyelitis and gangrene in the lower limbs. There are some risk factors for limb amputation due to DM such as aging, male gender, poor diabetic control, longer period of DM, and poor preventive health care (7).

According to the 14th edition of the Campbell's Operative Orthopaedics textbook, the amputation level depends on the infection site and the likelihood of ulcer healing. The only factor that is associated with a good outcome of diabetic foot amputation is the level of HbA1C. In the present study, we aimed to review the factors that could affect lower limb amputations following diabetic foot based on the recent literature.

Types of Amputation

Ray Amputation: Atway et al. recognized positive margin culture in three of 13 patients (23.1%) who had toe amputation. Ray amputation, which involves removal of the toe and part of the metatarsus, provides a better option for ensuring proper surgical debridement of septic margins. Symptoms may include wet or dry gangrene of the toe, osteoarthritis of the metatarsal head and/or proximal phalanx, septic arthritis of the metatarsophalangeal joint (MTPJ), and severe toe infection. Suggested criteria for classifying this type of amputation may include one or two palpable pedal pulses, ankle-brachial index (ABI) ≥ 0.8, and toe brachial index ≥ 0.7 (Figure 1) (8).

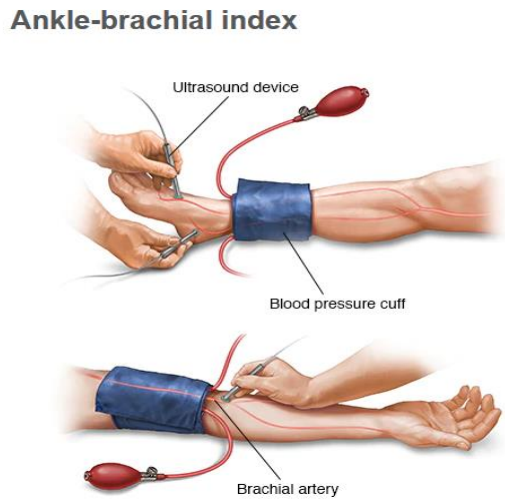

Figure 1. Ankle-brachial index (ABI)

In a study by Wong et al., they recognized a 70% of success rate in 150 patients with ray amputation in diabetic foot. There are some predictors of poor clinical outcomes for ray amputations such as absence of pulse, delayed capillary filling, and high erythrocyte sedimentation (9).

Transmetatarsal Amputation (TMA): TMA has some indications for diabetic foot such as involving only forefoot with wet or dry gangrene that might be associated with infection. In a retrospective study by Brown et al., they recognized high functioning level and durability of the stump in 21 patients undergoing TMA. However, they reported that this type of amputation had significant complication and failure rates (Figure 2) (10).

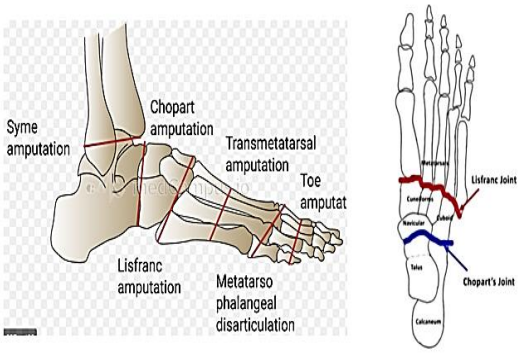

Figure 2. Levels of the foot amputations, including Syme, transmetatarsal, Lisfranc, and Chopart amputations

Lisfranc and Chopart Disarticulation: Lisfranc amputation is performed from the level of the tarsumatarsal joint (TMJ), while amputation is performed from the level of the Chopart joint through the talonavicular and calcaneocuboid joints (Figure 2). This amputation is rarely performed in a diabetic foot infection because of the high rate of failure and the proximity of the infected tissue to the heel pad. However, Brown et al. (10) reported high levels of ambulation for Chopart amputation in 10 patients. If complications can be avoided during and after surgery, it offers a desirable benefit for patients (Figure 2).

Syme Amputation: Syme amputation had good results for the patients with diabetic foot if they had palpable posterior tibial pulse and an ankle-brachial index of more than 0.5 (1719) (Figure 2) (10-12).

Pirogoff Amputation: In a study, Nather (13) reported acceptable outcomes with Pirogoff amputation for 6 patients with diabetic foot. The inclusion criteria of this amputation are a palpable posterior tibial pulse, ABI of more than 0.7, a hemoglobin level of more than 10 g/dl, and a serum albumin level of more than 30 g/l (Figure 3).

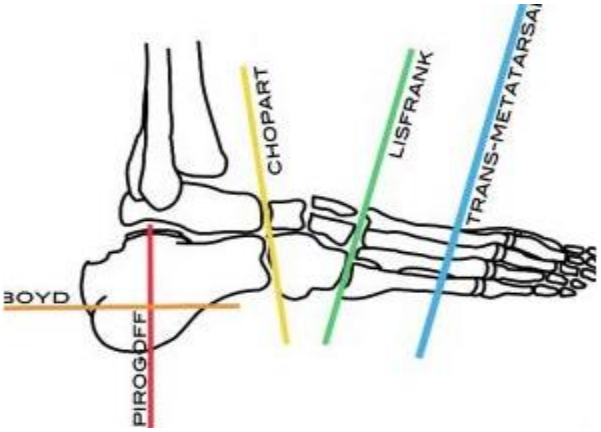

Figure 3. Levels of foot deformity

Factors Associated with Amputation

Palsson and Patel recognized that person-level factors had an independent association with amputation risk such as age, weight, visual acuity, and renal function. Cardiovascular and renal diseases had an independent association with poor outcome of the lower limb amputation (14).

ABI: Young et al. determined that the function of the circulatory and nervous systems had an independent association with the amputations risk. They revealed ABI level, which could show macrovascular disease, independently associated with amputation risk and success. An ABI < 0.5 had an association with poor outcome and higher risk for lower limb amputation as well as a high ABI greater than 1.3 had association with higher risk for amputation, and this condition may cause luminal stenosis and impaired perfusion (15).

Peripheral Neuropathy and Foot Vascular Malfunctioning: In a study conducted by Ohsawa et al. (16), it was found that peripheral neuropathy and foot vascular malfunctioning occur in terminal stages of DM. These two problems lead to the loss of protective sensation, poor healing of ulcers, and lowered resistance to infection.

Previous Ulcer: Karakoc et al. (17) and Ramsey et al. (18) presented that another risk factor for limb amputation includes having a previous ulcer. Toe disarticulations can be quite challenging for the surgeon when dealing with the remaining cartilage of the involved metatarsal head and possible complications of residual osteomyelitis.

Renal Impairment: Renal impairment is one of the major factor which has association with poor outcome of the amputation. Moreover, poor vision was also independently associated with higher amputation risk and may also serve as a marker for disease burden (14).

HbA1c: MacKinnon et al. recognized several factors associated with higher risk of amputation. They revealed some factors such as history of foot ulcer, high HbA1c, insulin use, and high systolic blood pressure (peripheral arterial disease). These factors may proceed by high HbA1c (19, 20).

History of Foot Ulcer and Amputation: Same as neuropathy and vascular disease, the history of ulceration and amputation had a contribution with poor outcome for lower limb amputation due to diabetic foot. Similarly, serum albumin may serve as a marker for inflammation and poor nutrition, and adjustment for factors related to either or both would have served to diminish its association with amputation risk (20, 21).

Charcot Deformity: Chronic neuropathy could cause Charcot deformity in patients with DM. This condition may affect the outcomes of the amputation and foot amputation is not appropriate for these patients. In most cases, they need higher level of amputation for better outcomes. (Figure 4) (20).

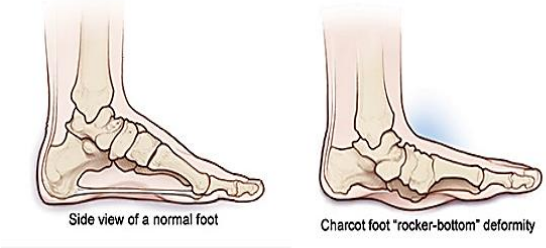

Figure 4. Charcot foot "rocker-bottom" deformity

Major Lower Limb Amputations Predictors

To determine the significant predictors for major lower limb amputation, we included the variables that were considered to be clinically important. The variables included duration of Type 2 DM (< 10 years vs. ≥ 10 years), Wagner classification (grade 1-3 vs. grade 4-5), positive bacterial culture (regardless of the type of bacterial specimen cultured), and plasma albumin level (22).

It was determined that age, gender, ethnicity, monthly income, dependency on family, smoking status, obesity, hyperlipidemia, hypertension, and history of ischemic heart disease were not associated with major lower limb amputation (22). The factors associated with major lower limb amputations included the Type 2 DM duration of ≥ 10 years, higher or tertiary education level, diabetic neuropathy, presentation with gangrene, diabetic foot condition of Wagner grade 4 or 5, and necrotizing fasciitis (22).

Duration of Type 2 DM: Type 2 DM duration ≥ 10 years, positive bacterial culture, and low albumin levels were found to be the significant predictive factors for major lower limb amputation among patients with Type 2 DM admitted for diabetic foot problems (22). Based on a 95% confidence interval level, the independent significant predictive factors for major lower limb amputations among our patients were duration of Type 2 DM of ≥ 10 years, positive bacterial culture, and low albumin levels (22).

Gangrene: Gangrene was a significant factor because 40.0% of patients with gangrene underwent major lower limb amputation compared to 10.1% of patients without gangrene. Coronary heart disease (CAD), abscesses, osteomyelitis, ulcers, and cellulitis were not significant factors for major lower limb amputation (22).

Amputation Level: Compared to those who underwent minor lower limb amputations, the patients who underwent major lower limb amputations were found to have significantly lower hemoglobin and albumin levels, higher white blood cell count, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), urea, and creatinine levels. A significantly higher number of patients who underwent major amputations also had a positive bacterial culture result compared to those who underwent minor amputations (22).

Necrotizing Fasciitis: Although necrotizing fasciitis was found to be associated with major lower limb amputation, following stepwise logistic regression, only a positive bacterial culture result was found to be a significant independent predictive factor for major lower limb amputation. Abscess, osteomyelitis, ulcers, and cellulitis were not significant factors for major lower limb amputation, suggesting that they could be treated with minor limb amputation (22).

White Blood Cell (WBC) Count: Aziz et al. observed that a total white blood cell count of more than 15.0 × 109/l was a predictive factor for major lower limb amputation, while ESR and CRP levels were only the associated factors (23). However, another study reported that the total WBC count, ESR, and CRP levels were dependent factors for major lower limb amputation (22).

Conclusion

Diabetic foot is one of the major complications of DM, which could affect the quality of life (QOL) of the patients and their socioeconomic level. Amputation is the treatment of the end stage diabetic ulceration, which could not heal, by conservative treatments. It is so important using the best level of the amputation for the patients to prevent from further surgeries and higher-level amputation. In this educational corner, we explained the factors affecting the amputation level.

Conflict of Interest

The authors declare no conflict of interest in this study.

Acknowledgments

None.

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