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Below-Knee and Syme Amputations: Comparative Review

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Abstract: Although amputation of the foot or lower leg is an unfortunate event, foot and ankle surgeons frequently encounter indications for these outcomes, including infection, trauma, vascular disease, and others. Amputation of a non-viable or non-functional foot may be accomplished via below-knee or Syme amputation. While both levels of amputation are valid surgical options, there has been debate regarding which is the more generally appropriate. Presented are findings in the literature comparing below-knee and Syme amputations with the intent to facilitate procedural selection in practice.

Key words: Amputation, below-knee, BKA, Transtibial, Syme

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While amputations have been performed for millennia, the first reported foot amputation by disarticulation at the ankle took place in 1842 at the hands of the Scottish surgeon James Syme.[1,2] In its original description, Syme innumerated three putative advantages of ankle disarticulation compared with below-knee amputation (BKA): lower mortality, greater stump comfort, and improved functionality of the residual limb.[1] The purpose of this article is to review available literature representing advantages and disadvantages of the below-knee and Syme amputations to help guide selection of the amputation level in clinical practice.

Mortality

Hospital records contemporary to Syme's own cases in Edinburgh show the mortality rate for "leg amputation" while one was hospitalized was 53%.[3] In studies from the 1980s, mortality rates of 6% to 13% were more typical within the 30-day period following BKA.[4] More currently, the rate of perioperative death following BKA has been estimated at 3.6-7.6%.[6-8]

Compared to the high rates of perioperative mortality seen with more proximal amputation, retrospective review of hospitalized patients for whom Syme performed his eponymous procedure revealed a considerably lower 11% in-hospital mortality rate.[3] There is little current data available regarding perioperative mortality for Syme amputation with two studies demonstrating no perioperative mortality in a combined total of 77 patients.[8-9]

Intermediate- and long-term mortality following BKA remains significant. A 2004 series including 704 patients who underwent BKA had 1- and 5- year mortality rates of 25.5% and 62.2%, respectively.[6] More currently, a 2011 study demonstrated rates of 21.8%, 32.9%, 52.1%, and 71.5% for 1-, 2-, 5-, and 10-year mortality following BKA, respectively.[5] Clearly defined intermediate- and long-term mortality rates following Syme amputation in current literature

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are lacking, however, though an estimated 5-year mortality rate of 40% has been previously cited.[8]

Wound Healing

Wound healing failure was reported in 18.8% of 626 patients who had undergone BKA in a 1986 study by Keagy et al.[4] This is consistent with reports from the same time period of about 80% wound healing among below-knee amputees.[4] Recent studies have demonstrated similar or improved wound healing after BKA. In 2006, Flaherty et al. reported a 90-day wound complication rate of 17% among 230 patients after BKA.[10] Hasanadka et al. found a 10.4% wound occurrence rate following BKA in patients with critical limb ischemia, including wound dehiscence in 1.7%, deep incisional infection in 2.9%, and superficial incisional infection in 5.1%.[11]

Wagner presented a series of 300 Syme amputations at Rancho Los Amigos Hospital in California in 1977.[12] Among these 2-stage Syme amputees, he reported a 70% success rate, with success defined as having healed the second stage wound and having worn a prosthesis.[12] Since then, studies have reported variable wound healing with the Syme amputation and study sizes are limited in comparison to studies of BKA. Jany and Burkus in 1988 reported 10 Syme amputations in patients with diabetes and peripheral vascular disease, among whom 50% did not heal the stump.[13] A series of 26 Syme amputations in 2006 found that 76.9% of amputees were able to heal the surgical incision (at a mean of 10 weeks), with 50% of patients remaining healed at mean follow-up of 49.3 weeks.[8] A local post-operative complication rate of 61.5% was noted in these patients, including dehiscence, recurrent osteomyelitis or infection, ischemia, and pressure ulceration.[8]

More recent evaluations of the Syme amputation have had improved rates of wound healing. Bibbo reported a series of 12 patients undergoing modified Syme amputation with a wound healing rate of 100% by six weeks, although one patient did develop flap necrosis at 8-weeks post-operatively.[14] Finkler et al. reported a 90% wound healing rate among 51 patients treated with Syme amputation for infection, crush injury, acquired foot deformity, or primary neoplasm.[9]

Functionality

The ability to ambulate post-operatively is a key goal for patients undergoing lower extremity amputation at any anatomic level. In 108 patients who had undergone BKA, Nehler et al. found that 61% of patients scheduled to follow-up at 6-months (actual mean follow-up: 10.3 months) and 65% of patients scheduled to follow-up at 12 months (actual mean follow-up: 17.5 months) were ambulatory indoors and/or outdoors.[15] There is considerable variability in ambulatory status after BKA in adults from study to study, likely a result of significant heterogeneity of patient populations. For example, Walker et al. reported in 1994 that 100% of 47 below-knee amputations were able to ambulate on flat ground with or without difficulty.[16] On the other end of the spectrum, Cruz et al. reported in 2003 that only 35% of below-knee amputees who were able to ambulate pre-operatively had the capability to do so afterward with or without the use of assistive device(s).[17] 66-71% of unilateral below-knee amputees have been ambulatory in other series.[4]

In 1990, Francis et al. presented data from 26 patients who underwent Syme amputation with only 46% able to walk after the procedure, despite a 77% stump healing rate.[18] 65.4% of 26 patients in the 2007 study by Frykberg et al. were able to ambulate after healing the Syme operative site, but only 46% remained ambulatory at a mean follow-up of 49.3 weeks.[8] Within 4-6 months of Syme amputation, Yu et al. found 90% of patients in a small, 10-patient series to be ambulatory without use of assistive device(s).[19]

A comparison of unrestrained walking among 13 below-knee and 15 Syme vascular amputees is included in a 1976 paper by Waters et al.[20] For BKA, patients' mean velocity, cadence, and stride length were found to be 45 m/min, 87 steps/min, and 1.02 m, respectively.[20] In all three of these aspects of gait, Syme amputation outperformed BKA with respective mean values 54 m/min, 98 steps/min, and 1.10 m.[20] Energy expenditure in this study also favored Syme somewhat with mean oxygen rate of 9.4 mL/kg per min and 9.2 mL/kg per min and mean oxygen cost of 0.20 mL/kg per m and 0.17 mL/kg per m, respectively, for below-knee and Syme amputations.[21] It is also worth mentioning that both BKA and Syme amputation offered considerably favorable results in

all examined gait parameters compared with vascular amputees who had undergone above-knee amputation (AKA).[21]

Prosthetic ease and function is another important aspect of lower extremity function after amputation. The below-knee stump and accompanying prostheses are effective and are well-established.[22-23] Historically, however, the Syme amputation has a reputation for prosthetic difficulty.[23] In a 1994 study of 87 lower extremity amputations at various levels with a mean 15-year follow-up, all seven of the included Syme disarticulations had stump problems related to friction in the Syme's prosthesis.[16] Additionally, only nine patients in the study responded as "very dissatisfied" with their amputation, including all seven of the Syme amputees.[16] A lower incidence of prosthetic failure was demonstrated in 25 below-knee amputees in a matched comparison with 25 patients with Syme amputation within Gaine and McCreath's 1996 study.[24]

Reamputation

Rates of revision for below-knee amputation to more proximal levels have remained fairly stable. The aforementioned study by Keagy et al. in 1986 had a revision rate of 18.8% for BKA to more proximal amputation, which is similar to the 17.6% reported in 2006 by Lim et al.[4,25] Lower revision rate was reported in 2004 by Aulivola et al. with only 9.4% of 704 BKAs progressing to more proximal amputation with mean follow-up 33.6 months.[6]

More proximal amputation was required after Syme amputation in 26.7% and 29% of patients from earlier studies in 1969 and 1986, respectively.[26-27] 50% of Syme amputees progressed to more proximal amputation in the 1988 10-case series by Jany and Burkus.[13] Gaine and McCreath's 1996 series of 46 Syme amputations, primarily for trauma or congenital deformities, saw 10 patients (21.7%) progress to BKA with a mean follow-up period of 22 years.[24]

Among more recent studies, there has also been considerable variability among revision rates status post Syme amputation. Frykberg et al. reported a revision rate of 38.5% among Syme amputees to BKA or AKA with mean follow-up of 49.3 weeks.[8] A single patient, 8.3% in the small 12-patient series, progressed to BKA after Syme amputation in the 2013 study by Bibbo.[14] 9.8% of Syme amputees went on to more proximal amputation in the 2017 study by Finkler et al.[9]

Conclusions

Heterogeneity of study populations, methods, and outcomes make objective comparison of below-knee and Syme amputations difficult, particularly given the smaller study populations and quantities of literature related to disarticulation at the ankle. Within this review, it may be worth noting that studies directed within the hegemony of pediatric orthopaedic surgery were excluded for the sake of relevance.

Perioperative and long-term mortality is lower with Syme amputation than with BKA upon review of the limited applicable literature. Syme amputation is more frequently accompanied by wound healing complications and re-amputation, though more recent literature suggest that healing rates for Syme amputation might be improving.

Functional recovery after amputation is highly dependent on the index population, but acceptable rates of functional rehabilitation and ambulation are achievable via BKA and Syme amputation. There is marginal benefit with regard to energy expenditure with Syme amputation compared to BKA. It is unlikely that the marginally improved energy expenditure seen with Syme amputations is worth patient dissatisfaction with the prosthesis and the potential for additional complications in most cases.

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