Distal amputations: impact of the introduction of femorocrural and femoropedal arterial bypass

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The aim of the study was to assess the impact of the introduction of femorodistal arterial bypass grafting on the patterns of lower limb amputation and reconstructive surgery, in particular the success rates of distal, conservative, amputations.

Two 2-year cohorts of patients 7 years apart were analysed by a retrospective analysis of departmental audit and patient records.

Significantly more patients undergoing distal amputation were considered to have reconstructible arterial disease in the later cohort. This was paralleled by an increase in the rate of suprapopliteal/popliteal and distal arterial bypass and a fall in below-knee amputation rate in this group of patients. The overall healing rate and rate of conversion of distal amputations were not adversely affected by the introduction of femorodistal bypass grafting, despite the fact that more distal amputees were non-diabetic in this second group. There was a high rate of success for distal amputations combined with femorodistal bypass, but the subgroup was too small for statistical analysis.

We conclude that the use of distal amputation, with or without distal arterial bypass, offers a promising, although unproven, prospect for lower limb conservation even in non-diabetics.

Arterial bypass grafting to the infrapopliteal vessels is one of the major innovations in vascular surgery over the last 10 years. Arterial reconstruction to crural or pedal vessels in occlusive vascular disease may permit the complete preservation of limbs previously thought to be unsalvageable. In addition, some patients who would have required major limb amputation may require only a limited distal amputation after successful femorocrural or femoropedal bypass.

We formulated the hypothesis that the introduction of femorocrural and femoropedal (collectively referred to as femorodistal) arterial bypass has altered the pattern of amputations performed in Oxford and led to more successful limited distal amputations than before the introduction. We have retrospectively analysed data for all infrainguinal arterial reconstructions and amputations performed in two 2-year periods before and after the introduction of femorodistal bypass to identify trends in practice. We then analysed all distal lower limb amputations performed for the same two periods, looking at amputation healing and ultimate amputation level as well as patient-related outcome data. We aimed to see whether the introduction of femorodistal bypass had affected the type of patient offered distal amputation and, if so, whether this had led to a change in outcome of the patient and the amputation.

Methods

Data were obtained from clinical notes of all patients identified from contemporary departmental audit records. Data from all patients who underwent distal amputation of the lower limb (defined as ankle disarticulation, foot
amputation or toe amputation) in the Nuffield Department of Surgery, Oxford, were gathered for two 2-year periods. The first, 1986 and 1987, was immediately before the introduction of femorodistal arterial bypass ('pre' group) and 1993 and 1994 were the last 2 years of complete data during which femorodistal arterial bypass grafts were performed ('post' group). In addition, summary data on all lower limb amputations and infrainguinal reconstructive surgery for the same two 2-year periods were gathered from the same departmental audit records.

In addition to routine demographic data, the following were recorded for all distal amputees:

1. The presence or absence of risk factors for occlusive arterial disease at the time of amputation, including diabetes mellitus.
2. The date, level and indication for amputation.
3. The status of the occlusive arterial disease of the lower limb.

The disease was classified as unreconstructible, reconstructible or no indication for reconstruction on the basis of intra-arterial or intravenous digital subtraction arteriography. These data were recorded in the notes, before amputation, at the routine weekly angiography conferences. Thus, the assessment of the arterial disease was made before and independent of the amputation and its outcome. Those who had undergone arterial reconstruction within the 3 months before amputation had the type and date of the reconstruction recorded. Reconstruction was considered to be any form of arterial reconstructive surgery to the infrainguinal vessels of that limb (including arterial bypass, endarterectomy and open angioplasty) or percutaneous angioplasty of the same limb. Unit policy over both time periods studied confined the indications for the use of arterial bypass surgery to limb salvage (rest pain or critical ischaemia) or non-healing ulceration.

4. The outcome of amputation up to 12 months postoperatively.

This was recorded as either death within the first 30 days postoperatively, healing or non-healing of the amputation as recorded in the notes. For non-healing wounds, subsequent operations on the limb were recorded including the final level of amputation. The rehabilitation outcome at 12 months after amputation was determined for the survivors from outpatient consultations held at 12 months. The parameters used to assess outcome were the ability to walk unassisted on at least one occasion a day and for everyday tasks, the use of a prosthesis on a regular basis and return to work, if employed preoperatively.

Patients who had distal amputations on both lower limbs during the study period(s), were included separately for each limb with the results being gathered for each limb.

Detailed analysis of the records of patients with bypass grafting was only carried out on those with combined distal amputations and femorodistal bypass grafting, there being only five such patients in the study in the 'post' group. All five patients had immediate postoperative graft patency confirmed, but graft surveillance was incomplete up to the chosen endpoint of the study (12 months after amputation).

Results

The numbers of amputations and infrainguinal reconstructive operations are shown in Fig. 1. The total operative workload was similar for both periods (248 vs 278 cases). There was a significant reduction in operation rates for all major amputations between the two groups (46% 'pre' vs 35% 'post', Z = 2.60, P < 0.01) (Z test for differences in percentages) with a significant difference between the two groups being due to a fall in the rate of below-knee amputation (BKA) from 28% 'pre' to 12% 'post' (χ² = 21.08, df = 2, P < 0.001) (χ² test). This was associated with a modest increase in through-knee amputation (TKA) rate (6% 'pre' to 14% 'post') and little change in above-knee amputation (AKA) rate. The rate of femorodistal bypass grafting rose from 2% 'pre' to 13% 'post' but there was little change in the rate of femoropopliteal (FemPop) grafting between the two groups.

Figure 1. Overall unit operative activity for infrainguinal bypasses and amputations 1993/1994 (top) 1986/1987 (bottom).
Table I. Patients undergoing distal amputations of the lower limb

<table>
<thead>
<tr>
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<th>1986/1987 (n = 36)</th>
<th>1993/1994 (n = 46)</th>
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</thead>
<tbody>
<tr>
<td>Median age/years (range)</td>
<td>68 (54–84)</td>
<td>72 (27–91)</td>
</tr>
<tr>
<td>Male</td>
<td>27 (75%)</td>
<td>33 (72%)</td>
</tr>
<tr>
<td>Female</td>
<td>9 (25%)</td>
<td>13 (28%)</td>
</tr>
<tr>
<td>Diabetics</td>
<td>23 (64%)</td>
<td>24 (52%)</td>
</tr>
<tr>
<td>Non-diabetics</td>
<td>13 (36%)</td>
<td>22 (48%)</td>
</tr>
</tbody>
</table>

In those patients undergoing distal amputation, 82 out of 91 (90%) had full data retrieved and collected. The remainder had incomplete or missing notes. The majority of these (seven) were from the ‘pre’ group owing to note archiving with loss of some data. One bilateral amputee was included in the ‘pre’ group and two in the ‘post’ group.

The demographic data are shown in Table I. There were no significant differences in age or sex between the two groups. The majority of distal amputations in both groups were performed for sepsis or dry gangrene and were digital or transmetatarsal.

Overall, of all distal amputees, significantly more of the ‘post’ group were considered to have reconstructible (46% ‘post’ vs 25% ‘pre’) rather than unreconstructible disease (46% ‘post’ vs 62% ‘pre’; \( \chi^2 = 3.85, df = 1, P < 0.05 \)) (Fig. 2). This was mirrored by a marked increase in previous femoropopliteal grafting in the ‘post’ group (14% to 28%) along with the introduction of earlier femorodistal grafting (0% to 11%) (angioplasty having a fairly constant use of between 6% and 12%) (Table II).

Interestingly, in the ‘post’ group of distal amputees more were non-diabetics, although this failed to reach significant levels using the fourfold \( \chi^2 \) test (48% ‘post’ vs 36% ‘pre’; \( \chi^2 = 1.13, df = 1, 0.10 < P < 0.50 \)). Despite this, there was no significant difference between 30 day mortality rate, healing rate or rate of subsequent conversion of the distal amputation to BKA or TKA (Table III).

Separate analysis of patients undergoing distal amputation with previous or synchronous femoropopliteal grafting (Table III) showed a non-significant increase in healing rate, again using the fourfold \( \chi^2 \) test (77% vs 50% \( \chi^2 = 1.07, P > 0.10 \)). Synchronous or earlier femorodistal grafting was associated with a healing rate of 80% (four out of five) and a rate of conversion to BKA or TKA of 20% (one out of five) with no 30 day mortality. However, the numbers involved were too small to be analysed statistically.

Statistical analysis of the results was performed using the Z test for differences in percentages. To assess the relative contributions of each element of the change, the \( \chi^2 \) test was applied. For changes in classification of vascular disease, the \( \chi^2 \) test was also applied, although, where applicable, for other data expressed in a 2×2 table, the modified (fourfold) \( \chi^2 \) test was used. All percentage figures were rounded to whole percentage points given the cohort sizes of 248 and 278 respectively, to prevent the spurious representation of accuracy.

Table II. Rates of arterial reconstruction performed before distal amputation

<table>
<thead>
<tr>
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<th>1986/1987 (n = 36)</th>
<th>1993/1994 (n = 46)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate of femoropopliteal grafting in amputees</td>
<td>4 (14%)</td>
<td>13 (28%)</td>
</tr>
<tr>
<td>Amputation healed</td>
<td>2 (50%)</td>
<td>10 (77%)</td>
</tr>
<tr>
<td>Amputation non-healed</td>
<td>2 (50%)</td>
<td>3 (23%)</td>
</tr>
<tr>
<td>Rate of femorodistal grafting in amputees</td>
<td>0</td>
<td>5 (11%)</td>
</tr>
<tr>
<td>Amputation healed</td>
<td>0</td>
<td>4 (80%)</td>
</tr>
<tr>
<td>Amputation non-healed</td>
<td>0</td>
<td>1 (20%)</td>
</tr>
<tr>
<td>Rate of angioplasty in amputees</td>
<td>3 (11%)</td>
<td>3 (6%)</td>
</tr>
<tr>
<td>Amputation healed</td>
<td>3 (100%)</td>
<td>2 (67%)</td>
</tr>
<tr>
<td>Amputation non-healed</td>
<td>0</td>
<td>1 (33%)</td>
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Table III. Results of distal amputation of the lower limb

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<tbody>
<tr>
<td>Overall healing rate of distal amputations</td>
<td>21 (58%)</td>
<td>30 (65%)</td>
<td>3 (80%)</td>
</tr>
<tr>
<td>Rate of subsequent conversion to BKA or TKA</td>
<td>7 (19%)</td>
<td>9 (20%)</td>
<td>1 (20%)</td>
</tr>
<tr>
<td>Rate of subsequent conversion to other distal amputations</td>
<td>0</td>
<td>3 (7%)</td>
<td>0</td>
</tr>
<tr>
<td>30-day mortality</td>
<td>2 (6%)</td>
<td>1 (2%)</td>
<td>0</td>
</tr>
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</table>
Discussion

Amputations through and below the knee often require the sacrifice of apparently viable tissue in the leg and foot when only the foot or toes are ischaemic. There is debate regarding strategies to reduce unnecessary tissue sacrifice. Several authors have reported the use of distal amputations of the foot and ankle in peripheral vascular disease in an effort to prevent loss of the ankle joint or distal tibia as a weight-bearing surface (1,2). Others have reported rates of salvage for the leg of up to 84% in combination with femorodistal arterial bypass (3). Other studies have shown a rise in the rate of healing of transmetatarsal distal amputation from 24% to 62% where reconstruction to either popliteal or distal vessels was possible (4,5). All of these studies have shown no difference between diabetic and non-diabetic subgroups. There is some evidence that distal arterial reconstruction is a useful tool in the salvage of non-healing ischaemic distal amputations (6), but no studies have attempted to identify the impact of the introduction of distal reconstruction on distal amputation outcome. There is some evidence that preceding or synchronous distal arterial reconstruction does not adversely affect the outcome of amputations (7–10). Our data support this view, with conversion rates to other, more major, proximal amputations remaining almost unchanged.

Above-knee amputations and femoropopliteal arterial bypass can be seen as indirect measures of ‘severe non-reconstructible’ and ‘severe but reconstructible’ proximal (popliteal and suprapopliteal) disease, respectively. If this is so, the figures for these two operations for the two overall groups support the view that the pattern of operative management of proximal disease has not changed significantly.

Since the introduction of distal arterial bypass, the rate for all major amputations performed (AKA, TKA, BKA) fell significantly to only 76% of its 1986/1987 level—a fall of 11 percentage points (46% ‘pre’ vs 35% ‘post’). In particular, the rate of BKA has fallen significantly. This fall in the rate of BKA may partly be explained by a change in unit surgical preference. In the latter group, patients deemed to be ‘non-walkers’ were offered through-knee amputation in an attempt to decrease the rate of amputation failure (11). However, the increase in TKA rate is insufficient on its own to explain the change completely. Two other explanations are compatible with the data. First, patients previously thought to have unreconstructible disease and given major ablative amputations, may now be being considered reconstructible (as suggested by the data in Fig. 2). They may now be being successfully offered distal arterial bypass avoiding amputation altogether (as suggested by the rise in the overall femorodistal grafting rate) or offered proximal reconstruction with subsequent selective distal amputation (as suggested by the rise in the rate of femoropopliteal grafting before distal amputation). We have not addressed whether or not this was the case, although the increased use of and success of femoropopliteal grafting in the latter group is encouraging despite the small numbers involved.

Alternatively, patients, particularly non-diabetics, previously offered proximal amputations, may now be being offered conservative distal amputations with or without distal reconstructive surgery. Our results for all distal amputees show that despite the increase in non-diabetics having distal amputations (a group traditionally associated with a poor outcome) the 30 day mortality is lower and the healing rate and conversion rate to higher amputations (BKAs or TKAs) have remained unchanged. Indeed, in those limbs in which distal grafting was used, the healing rate was encouragingly high, although numbers are too small to allow statistical analysis. These data offer some support to the view that distal amputation combined with distal bypass grafting is associated with an increased success rate for amputation. Although the paucity of numbers is a shortcoming, continued use of combined distal grafting and conservative distal amputation may, in future, allow a further analysis of this subgroup. Until such a study is possible, we believe that the evidence is sufficient to justify continued use of distal amputation with or without distal grafting and that this policy offers a promising prospect for providing lower limb conservation in certain patients, including those with non-diabetic occlusive arterial disease.

We conclude that the introduction of femorodistal bypass grafting has been associated with a reduction in the lower limb major amputation rate, particularly BKAs. This has been accompanied by an increasing use of distal reconstructive surgery for limb salvage. Distal amputations offer a promising prospect for providing lower limb conservation in certain patients and may safely be employed in non-diabetics with equally good results. Where femorodistal bypass grafting is combined with distal amputation there is some evidence for even greater success, although further work is needed on larger numbers of patients.

References


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