Flinders UNIVERSITY

Title: Physiotherapy rehabilitation for individuals with lower limb amputation: A 15 year clinical series.

ABSTRACT

Background and Purpose. Individuals with amputations are a core group in Australian rehabilitation units who have a long index length of stay (LOS). The Repatriation General Hospital (RGH) offers general rehabilitation services to the population of Southern Adelaide (population 350,000) and includes an on-site prosthetic manufacturing facility. Using a physiotherapy database at RGH, we sought to answer the following questions: What are the demographic and clinical characteristics of patients admitted for lower limb prosthetic rehabilitation over 15 years? What are the times to rehabilitation outcomes? How have these changed over 15 years with changes in service delivery? **Methods.** Retrospective observational study using a physiotherapy clinical database (1996-2010) of 531 consecutive individuals with lower limb amputation at one South Australian hospital (RGH). Two changes in service delivery: (1) A multidisciplinary interim prosthetic program (IPP) introduced in 1998, and (2) removable rigid dressings (RRD's) introduced in 2000. Outcome measures were patient demographics, clinical characteristics and time to rehabilitation outcome markers. **Results.** Mean age was 68 years (SD 15) with 69% male, 80% dysvascular and 68% transtibial. The overall median inpatient rehabilitation length of stay was 39 days (IQR 26-57). Individuals with amputation entering rehabilitation each year had a higher number of comorbidities (β: 0.08; 95% CI: 0.05-0.11). Introduction of the IPP was associated with a significant reduction in time to initial prosthetic casting, independent walk and inpatient RLOS. Introduction of RRD's was associated with a significant reduction in time to wound healing, initial prosthetic casting and independent walk. **Conclusions.** Individuals with amputation were typically elderly, dysvascular, males with transtibial amputations. ~~Independent walk is an outcome rarely reported and is~~

~~significant for patients and clinicians~~. Introduction of the IPP and RRD's successfully reduced time to rehabilitation outcomes including independent walk; an outcome which is rarely reported but is of significance to patients and physiotherapists. ~~However it appears times to clinical outcomes were increasing and may be due to a change in profile of individuals with amputation admitted for prosthetic rehabilitation.~~

INTRODUCTION

Improvements in amputee outcomes have occurred as a result of new medical and surgical innovations, but amputation numbers remain high and rehabilitation of individuals with amputation continues to be a core business for medical rehabilitation units across the world. Most individuals with lower limb amputation in the developed world are elderly, dysvascular patients, often presenting with diabetes mellitus (DM) (Pernot et al., 2000; Nehler et al., 2003; Stone et al., 2007). It is estimated that 700,000 Australians (3.6% population) were diagnosed with DM and 3,394 diabetic related lower limb amputations were performed in Australia in 2004-05 (Australian Institute of Health and Welfare, 2008).

Individuals with amputation are a core group in Australian rehabilitation units who have a long index length of stay (LOS). The long LOS associated with the index admission is justified by clinicians as important because restoring independent mobility and community integration reduces the larger social and health service costs associated with disability. It is widely believed that growth of interventional vascular surgery has helped reduce lower limb amputation numbers in dysvascular patients (Feinglass et al., 1999; Nowygrod et al., 2006). However, it is unknown whether the demographics of individuals with amputation entering rehabilitation units now have changed~~present with different demographics than previously~~. This may result in a change in the outcomes achieved, time taken to achieve these outcomes or in the nature of the clinical programs provided by physiotherapists. National outcome data collected by the Australian Rehabilitation Outcomes Centre (AROC) suggests there are wide variations in

physiotherapy practice across Australia but at this stage information on clinical practice is lacking (AROC, 2010).

~~Literature reporting~~ Data from prosthetic rehabilitation hospital cohorts ~~lower limb amputee cohorts~~ in Australia ~~prosthetic rehabilitation facilities~~ is limited. Six studies were identified (Katrak and Baggott, 1980; Hubbard, 1989; Jones, 1990; Jones et al., 1993; Lim et al., 2006; Wu et al., 2010) with all reporting demographics and clinical characteristics of the cohorts. However, only inpatient rehabilitation length of stay (RLOS) was reported as an outcome and the identified studies failed to investigate other rehabilitation outcomes such as times to wound healing, initial prosthetic casting and independent walk. Successful wound healing is an important rehabilitation marker as it allows rehabilitation with a physiotherapist to progress towards mobilising with a prosthesis. ~~Wound healing and prosthetic casting often happen within similar timeframes and time to initial prosthetic casting is used as an indication of wound healing (Nawijn et al., 2005).~~ Reported times from amputation to initial prosthetic casting ~~in Australian rehabilitation facilities~~ vary, ranging from 36.4 days (IQR 24-50) with soft dressings (Taylor et al., 2008) to 23.3 days (SD 19.5) with removable rigid dressings (RRD's) (Deutsch et al., 2005). A review by Van Velzen et al. (2006) reported that 56-97% of individuals with amputation~~amputees~~ regain the ability to walk, however time to independent walk is rarely reported in the literature. Independent ~~walking~~ walking with a prosthesis remains the key outcome for a physiotherapist in an~~n~~ amputee rehabilitation service ~~because~~ as it allows patients to work towards achieving independence and will likely contribute to improved quality of life (Pell et al., 1993; Hamamura et al., 2009).

The Repatriation General Hospital (RGH) offers general rehabilitation services to the population of Southern Adelaide (population 350,000) and includes an on-site prosthetic manufacturing facility. ~~Each morning~~ Individuals with lower limb amputation ~~amputees~~ attend a multidisciplinary gym session with a dedicated amputee physiotherapist and prosthetist. Six sessions are conducted per week in a group setting. Sessions include upper and lower limb strengthening, prosthetic fitting and modification, balance and gait re-education. Physiotherapy forms only part of the multidisciplinary rehabilitation service offered to individuals with amputation at RGH. Other services are provided by rehabilitation medical consultants, rehabilitation nursing, occupational therapy (for home modifications, return to driving and return to work), social work, psychology services (if required) and dietetics (if required). During the period of observation, two significant changes in service delivery occurred. In 1998 an interim prosthetic program (IPP) was implemented which resulted in streamlined multidisciplinary services, and provided patients with an interim prosthesis which incorporated a laminated prosthetic socket with modular componentry (made by a prosthetist) (see figure 1). No interim prosthesis was used prior to this and gait retraining was achieved with an air bag system (pneumatic post amputation mobility aid) for transtibial, knee disarticulation and transfemoral patients. Routine fitting of RRD's was introduced in 2000 (fitted by a prosthetist) for individuals with transtibial amputation~~amputees~~ (current practice dictates that individuals with transfemoral amputation are not managed with RRD's). Fitting occurred immediately post operatively or within 24 hours. The evidence supporting RRD's indicates a reduction in; edema (Mueller, 1982; Nawijn et al., 2005), time from amputation to wound healing (Deutsch et al., 2005; Nawijn et al., 2005) ~~and~~

time from amputation to initial prosthetic casting (Wu et al., 1979; Hughes et al., 1998; Woodburn et al., 2004; Taylor et al., 2008) and RLOS (Taylor et al., 2008).

Using a physiotherapy database of patients who received rehabilitation for a lower limb amputation between 1st January 1996 and 31st December 2010 at RGH, we sought to answer the following questions:

1. What are the demographics and clinical characteristics of patients individuals with lower limb amputation admitted for lower limb prosthetic rehabilitation and how have these changed over the observation period?
2. What are the times to rehabilitation outcomes (wound healing, initial prosthetic casting, independent walk and inpatient RLOS)?
3. How have demographics, clinical characteristics and the changing model of rehabilitation services offered at RGH affected rehabilitation outcomes?

METHOD

Design

This study was a retrospective audit of a Cclinical physiotherapy database of consecutive individuals with lower limb amputation amputees admitted for prosthetic rehabilitation at RGH between January 1st 1996 and December 31st 2010 were audited. The period 1996 to 2010 marks the beginning of inpatient amputee rehabilitation at RGH to the most recent completed year of data at time of writing. Records were examined by two authors (BH and VB) and data were extracted for analysis. Extracted data included demographics, clinical characteristics and rehabilitation outcomes. Ethical

approval was provided by the Southern Adelaide Flinders Clinical Human Research Ethics Committee.

Subjects

The RGH provides inpatient and outpatient prosthetic rehabilitation for individuals with major lower limb amputation~~amputees~~. Amputation types included were transtibial, transfemoral, knee disarticulation, hip disarticulation, unilateral and bilateral. Acute amputation services were provided by both RGH, and hospitals which are geographically separate to RGH.

Outcome measures

The primary rehabilitation outcome markers were; wound healing, initial prosthetic casting, independent walk and inpatient RLOS. A secondary measure of total rehabilitation program duration (RPD) was also reported. Wound healing was determined from visual inspection by the amputee physiotherapist and prosthetist, and confirmed with the rehabilitation medical consultant. Independent ~~walk~~ walking was determined by the amputee physiotherapist when the patient could mobilise 10 metres independently (with or without gait aid). Inpatient RLOS was defined as the timeframe from when an individual with amputation~~amputee~~ was admitted to RGH as an inpatient for prosthetic rehabilitation, to discharge from RGH. Total RPD include~~d~~s inpatient RLOS and rehabilitation conducted as an outpatient. 'Length of stay' in hospitals is an outcome measure which can be difficult to interpret. While in some health systems it may be a surrogate for morbidity, in other systems it may represent patient preference, insurance company requirements or a lack of ambulatory alternatives (La Cour et al.,

2010). In our study we used 'length of stay' as a surrogate for morbidity, lack of ambulatory alternatives (i.e. inability to further progress mobility of the patient), lack of discharge destination preparation (i.e. delays in home modifications) and patient preference (home or hospital based rehabilitation)~~in our study~~. Insurance company requirements did not equally apply as a surrogate of RLOS to this dataset. This is due to RGH being a publically funded hospital. Rehabilitation outcome markers were recorded in days post amputation and days post beginning rehabilitation. Information on patient demographics and clinical characteristics including age, gender, indication for amputation, level of amputation, complications, comorbidities and discharge destination was also collected.

Data analysis

Regression analysis was conducted to model the age, total number of comorbidities and admission numbers of individuals with amputation~~amputees~~ entering rehabilitation over the 15 year observation period. Results are reported with a regression coefficient (β) with 95% confidence interval (CI). Logistic regression analysis was used to model discharge destinations and results are reported with an odds ratio (OR) with 95% CI. Zero truncated negative binomial regression was used to model times to wound healing, initial prosthetic casting, independent walk and inpatient RLOS. Observations from patients who did not realize a particular rehabilitation outcome were excluded from the analysis. Zero truncated negative binomial regression accounts for over dispersion and the fact that all outcomes are counts greater than zero. Results are reported as an incidence rate ratio (IRR) with 95% CI. An IRR is a ratio which describes the relative rates of experiencing an outcome given an exposure. All multivariable models were

adjusted for covariates as footnoted in the table. Models were fitted with terms in polynomial time up to the third power as appropriate in order to explain variation over the period of the study. A p-value of 0.05 (two-tailed) was considered statistically significant. All analyses were performed using Stata 11.2 for Windows (StataCorp, 2009).

RESULTS

Outcome of ~~Patients~~ patients through ~~R~~rehabilitation

A total of 531 consecutive individuals with amputation were admitted for prosthetic rehabilitation at RGH between 1996 and 2010. Figure 2 presents the flow of patients through to the completion of rehabilitation. No significant difference was found in admission numbers per year over the observation period (β: 0.63; 95% CI: -0.34-1.61).

Patient demographics and clinical characteristics

Table 1 summarises patient demographics and clinical characteristics. Results indicate that age significantly decreased across the observation period (β: 0.49; 95% CI: 0.20-0.79), whilst total number of comorbidities increased across the observation period (β: 0.08; 95% CI: 0.05-0.11) (see table 2). The number of individuals with amputation ~~amputees~~ discharged home also decreased across the observation period (OR: 0.92; 95% CI: 0.86-0.99) (see table 2). From 1996 to 2003, 8 patients were re-admitted to hospital, whilst from 2004 to 2010, 41 patients were re-admitted to hospital.

Rehabilitation outcomes

Figure 2 presents results of rehabilitation outcomes of the 531 patients admitted for

prosthetic rehabilitation at RGH. Time to rehabilitation outcomes at the beginning (1996) and end (2010) of the observation period are presented in table ~~2~~3.

Effect of demographics, clinical characteristics and the changing model of rehabilitation services on rehabilitation outcomes

Results for the rehabilitation outcomes wound healing, initial prosthetic casting, independent walk and inpatient RLOS are presented in figures 3 and 4. Multivariable predictors of times to wound healing, initial prosthetic casting, independent walk and inpatient RLOS are summarised in table ~~3~~4. The introduction of the IPP was associated with a significant reduction in time to cast (IRR: 0.64; 95% CI: 0.56-0.72), independent walk (IRR: 0.80; 95% CI: 0.73-0.87) and inpatient RLOS (IRR: 0.49; 95% CI: 0.30-0.79). Introduction of RRD's (applied to transtibial amputees only) was associated with a significant reduction in time to wound healing (IRR: 0.33; 95% CI: 0.27-0.40), prosthetic casting (IRR: 0.65; 95% CI: 0.57-0.73) and independent walk (IRR: 0.87; 95% CI: 0.76-1.00).

DISCUSSION

The aim of the present study was to describe changes in the demographics and clinical characteristics of individuals with lower limb amputation admitted to a Southern Adelaide area hospital for rehabilitation, and to determine how changes in these characteristics and service delivery over the period of observation have affected rehabilitation outcomes in the patient population. From these findings we intend to discuss the broader significance to physiotherapists working with individuals with lower limb amputations.

Patient demographics and clinical characteristics

Age, gender and indication for amputation of this cohort are similar to that reported by other recent Australian and international amputee rehabilitation cohorts (Rommers et al., 1996; Kazmers et al., 2000; Toursarkissian et al., 2002; Cruz et al., 2003; Nehler et al., 2003; Aulivola et al., 2004; Lim et al., 2006; Wu et al., 2010) . A higher percentage of transtibial amputees were admitted to RGH (68%) compared to previous published data (44%-59%), while a lower percentage of individuals with transfemoral amputation (22%) were seen compared to earlier data (26-55%) (Katrak and Baggott, 1980; Hubbard, 1989; Jones et al., 1993; Kazmers et al., 2000; Nehler et al., 2003; Lim et al., 2006). However, comparison with a more recent Australian cohort covering a similar observation period (1994-2006) reveals a similar percentage of transtibial amputees admitted for rehabilitation (66%) (Wu et al., 2010). We believe the reported differences compared to historical published data are a reflection of the predominantly dysvascular nature of individuals with amputation admitted to RGH, advances and improvements in limb salvage surgery, diabetic care, foot care and wound management which have occurred in recent years.

Across the observation period there was a decrease in the number of individuals with lower limb amputation discharged home despite the average age of patients decreasing significantly. We believe one of the major reasons for this trend was the increasing number of comorbidities observed in this population which meant that overall patients were frailer and less appropriate for discharge home. One of the most common comorbidities in this population was type 2 diabetes mellitus. It is known that the

incidence of type 2 diabetes mellitus is increasing worldwide, primarily because of increasing prevalence of obesity and physical inactivity (Wild et al., 2004; Eckel et al., 2005; Hu, 2011). Clinicians, including physiotherapists, may need to consider the implementation of chronic disease self-management approaches to promote changes leading to more healthy lifestyles amongst the amputee population (Tuomilehto et al., 2001; Heideman et al., 2011; Hu, 2011).

Rehabilitation outcomes

Identifying improvements in the amputee rehabilitation service relied upon identifying important clinical outcomes and measuring them as changes were made to the service during the period of observation. Four primary outcomes were used in this study to monitor patient rehabilitation – wound healing, initial prosthetic casting, independent walk and inpatient RLOS. Wound healing and time to first prosthetic casting are traditional milestones in amputee rehabilitation as early successful wound healing allows progression to further rehabilitation, including mobility with a prosthesis. The initial aim of clinicians, practitioners and medical staff is to promote wound healing since early successful wound healing is often immediately followed by prosthetic casting (Nawijn et al., 2005), as was demonstrated by the present data. We found time from amputation to first prosthetic casting was similar to time frames reported in previous studies (Deutsch et al., 2005; Taylor et al., 2008). The initial casting for a prosthetic socket will lead to use of an interim prosthesis and a more intesive phase of rehabilitation with the ultimate goal being to achieve independent walking,

In contrast the time taken to achieve independent walking, which is a key rehabilitation

goal for individuals with lower limb amputation and amputee physiotherapists, is not well reported in the literature. The ability to walk independently was achieved by a high percentage of patients (83%) in this study. This is well within the range (56%-97%) reported by Van Velzen et al., (2006). However, there was more variation in the time taken to achieve an independent walk in the current data due to changes in service delivery over the observation period. We believe reporting on time to independent walk should be included as a key measure in amputee rehabilitation studies to inform improvements in physiotherapy service delivery.

Effect of service delivery changes on rehabilitation outcomes

Interim prosthetic programs vary across rehabilitation sites. Only one previous study comparing a public and private IPP model could be found, but did not report on outcomes used in this study (Gordon et al., 2010). During the period of observation, the introduction of the IPP was associated with a significant reduction in the time taken to achieve initial prosthetic casting, independent walking and inpatient RLOS, suggesting it is a valuable part of a service model. The reduction in time to initial prosthetic casting was not unexpected as the program supplied patients with an interim prosthesis which was not done previously. However, the reduction in time to independent walk has not been reported previously and is an important milestone for the patient in regaining independence (Pell et al., 1993; Hamamura et al., 2009). We believe the reduction is primarily due to the IPP providing access to an interim prosthesis (figure 1), enabling individuals with lower limb amputation to practice more appropriate patterns of weight shifting, stepping and walking with a physiotherapist sooner in the rehabilitation phase. Physiotherapists working with individuals with lower limb amputations are encouraged

to initiate service modifications, such as an IPP if one is not already in place, which facilitate mobility retraining as soon as possible in the rehabilitation process.

The use of RRD's with individuals with transtibial amputation should now be common practice in many services across the developed world. The introduction of RRD's occurred in 2000 at RGH and was associated with a significant reduction in time from amputation to wound healing, initial prosthetic casting and independent walk for individuals with transtibial amputation. These findings are consistent with previous evidence which has demonstrated RRD's reduce time to wound healing (Deutsch et al., 2005; Nawijn et al., 2005), time to initial prosthetic casting (Wu et al., 1979; Hughes et al., 1998; Woodburn et al., 2004; Taylor et al., 2008) and RLOS (Taylor et al., 2008). However, this study provides some of the first evidence to suggest that their use is associated with a reduction in the time taken to achieve independent walking. This is a key finding for physiotherapists as they are often primarily concerned with restoring the mobility of their patients. In consultation with treating physiotherapists and prosthetists, amputee rehabilitation services should ensure that individuals with transtibial amputation are provided with RRD's following limb amputation in accordance with best practice guidelines.

Despite the introduction of the IPP and RRD's it is interesting to note that times to initial prosthetic casting, independent walk and inpatient RLOS based on IRR's are increasing towards the end of the observation period (see figure 3 and 4). We speculate these increases may be due to the earlier stage in acute recovery at which individuals with lower limb amputation are admitted to rehabilitation from acute hospital services.

Whilst this process may reduce acute hospital LOS, it may impact negatively on RLOS. However, this may be countered by the benefit of earlier exposure to physiotherapy rehabilitation services. These changes may also be due to the increase in a more comorbid population that is admitted for rehabilitation and indicate the need for an amputee rehabilitation service better tailored for this population. Further investigation is required into the increasing time to rehabilitation outcomes and how service provision can be improved to address these trends.

Limitations

Our study was based at a single institution and there are likely to be differences in admission criteria and services provided to patients and therefore results may not be generalisable to other amputee rehabilitation facilities. Further limitations of this study include the retrospective nature of the analysis which relied upon the quality of documentation and recording in the physiotherapy clinical database and medical notes. Not all desirable data was available to undertake a complete and thorough analysis of the outcomes of the amputee rehabilitation service. For example, information regarding residual limb (stump) length, surgical technique, prosthetic equipment and premorbid mobility are all factors which were not documented in this study, but are likely to influence amputee rehabilitation outcomes. Finally, no follow-up of function in the community was conducted to determine the long term outcomes from the amputee rehabilitation.

Summary

In the present cohort, individuals with lower limb amputation were typically elderly,

dysvascular, males with transtibial amputations. Introduction of the IPP and RRD's successfully reduced time to all primary rehabilitation outcomes including, time to wound healing, initial prosthetic casting, independent walk, and inpatient RLOS.

Implications

Three implications relevant for amputee physiotherapists and clinicians can be drawn from this study. We believe time to independent walk is an outcome of value which should be tracked by physiotherapists. For the present cohort it has proven a useful outcome in assessing the effectiveness of service modifications during the period of observation. Secondly physiotherapists need to consider service modifications which would enable individuals to undertake mobility retraining earlier in their rehabilitation to reduce time to rehabilitation milestones. Finally, in light of the changing characteristics of individuals with lower limb amputation now presenting for rehabilitation described in this study it is likely physiotherapists, and clinicians in general, will need to tailor services to target this younger, more comorbid, population.

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Table 1 Mean (SD) or n (%) of patient demographics and clinical characteristics.

Clinical Characteristics	Participants (n = 531)
Age (years)	68 (SD 15)
Gender	
Male	367 (69%)
Female	164 (31%)
Indication	426 (80%)
Dysvascular	250 (59%)
Dysvascular with Diabetes	44 (8%)
Trauma	15 (3%)
Tumour	22 (4%)
Infection	24 (5%)
Other	
Type	
Trans-tibial	361 (68%)
Trans-femoral	116 (22%)
Knee disarticulation	4 (1%)
Hip disarticulation	6 (1%)
Bilateral trans-tibial	29 (5%)
Bilateral trans-femoral	3 (1%)
Bilateral trans tib/fem	12 (2%)
Discharge Destination	
Home	327 (76%)
Transitional care	19 (4%)
Hospital	49 (11%)
Hostel	21 (5%)
Nursing home	12 (3%)
Deceased	1 (0%)
Comorbidities	
PVD (peripheral vascular disease)	329 (62%)
DM (diabetes mellitus)	261 (49%)
IHD (interstitial heart disease)	163 (31%)
OA (osteoarthritis)	43 (8%)
HT (hypertension)	143 (27%)
CRF (chronic renal failure)	52 (10%)
Previous amputation	49 (9%)

Table 2 Number of admissions, mean (SD) age of patients, mean (SD) number of comorbidities and discharge home (%) each year of observation.

Year	Admissions (n)	Age (years)	Comorbidities (n)	Discharge Home (%)
1996	38	69.7 (13.1)	2.3 (1.0)	81
1997	25	70.2 (9.5)	2.5 (1.4)	77
1998	21	70.7 (14.5)	2.2 (1.4)	91
1999	35	73.6 (10.5)	2.8 (1.3)	92
2000	33	70.4 (13.1)	2.5 (1.2)	79
2001	35	71.1 (13.9)	3.0 (1.8)	65
2002	26	73.0 (11.7)	3.0 (1.6)	88
2003	49	67.6 (17.3)	3.4 (1.8)	80
2004	49	66.6 (19.1)	2.9 (1.6)	69
2005	35	67.2 (17.2)	3.3 (1.7)	80
2006	43	68.9 (12.6)	3.2 (1.8)	71
2007	33	66.2 (16.1)	3.5 (1.9)	67
2008	37	64.4 (12.9)	3.4 (2.0)	77
2009	36	65.8 (16.5)	3.4 (1.8)	64
2010	36	65.1 (13.9)	3.3 (1.7)	91

Table ~~2~~3 Median (IQR) for rehabilitation outcomes in days post amputation and days post beginning rehabilitation

	Days Post Amputation			Rehabilitation Days		
Year (Admissions)	1996 (38)	2010 (36)	All (531)	1996 (38)	2010 (36)	All (531)
Outcome Marker						
Start PT Physiotherapy	46 (36-70)	14.5 (8-27)	15 (9-38)	N/A	N/A	N/A
Wound Healing	51 (36-79)	25 (21-35)	27 (22-54)	1 (1-1)	11 (1-14)	10 (1-17)
Prosthetic Casting	62.5 (44-80)	34 (27-62)	31.5 (24-60)	9 (4-20)	22 (15-28)	14 (8-22)
Independent Walk	105 (66-150)	61 (43-93)	68 (48-110)	30 (22-78)	47 (31–77)	45 (29-71)
Inpatient RLOS	N/A	N/A	N/A	34.5 (21.5-48.5)	43 (33-57)	39 (26-57)
Total RPD	147.5 (111- 225)	124 (70-154)	133 (93-198)	84 (57–136)	103.5(58-135)	106 (65-155)

Table ~~34~~ Predictors of rehabilitation outcome measures.

	Wound Healing	Initial Prosthetic Casting	Independent Walk	Inpatient RLOS
	Multivariable IRR (95% CI)	Multivariable IRR (95% CI)	Multivariable IRR (95% CI)	Multivariable IRR (95% CI)
Time				
1996 (ref)	1.00	1.00	1.00	1.00
2002	0.39 (0.12, 1.31)	1.15 (0.98, 1.36)	**1.19 (1.11, 1.27)*** **	**5.03 (2.22, 11.41)*** **
2010	0.39 (0.12, 1.31)	1.40 (0.96, 2.03)	**1.50 (1.13, 1.87)*** **	**4.46 (2.06, 9.68)*** **
IPP~	1.22 (0.69, 2.17)	**0.64 (0.56, 0.72)*** **	**0.80 (0.73, 0.87)** **	**0.49 (0.30, 0.79)** **
RRD #	**0.33 (0.27, 0.40)*** **	**0.65 (0.57, 0.73)*** **	**0.87 (0.76, 1.00)***	1.15 (0.97, 1.36)
Age	1.00 (1.00, 1.01)	1.00 (1.00, 1.00)	**1.01 (1.01, 1.02)*** **	**-**
1996	-	-	-	**1.03 (1.02, 1.04)*** **
2002	-	-	-	**1.02 (1.01, 1.02)*** **
2010	-	-	-	1.00 (0.99, 1.00)
Gender				
Male (ref)	1.00	1.00	1.00	1.00
Female	**1.18 (1.03, 1.36)***	1.07 (1.00, 1.15)	1.07 (0.99, 1.16)	1.06 (0.94, 1.19)
Amputation type				
Transtibial (ref)	1.00	1.00	1.00	1.00
Transfemoral	**0.68 (0.56, 0.82)*** **	1.06 (0.86, 1.26)	**1.16 (1.07, 1.27)*** **	**0.85 (0.75, 0.97)***
Bilateral	0.96 (0.75, 1.23)	1.13 (1.00, 1.27)	**1.33 (1.17, 1.50)*** **	1.16 (0.95, 1.41)
Cause				
Dysvascular (ref)	1.00	1.00	1.00	1.00
Dysvascular DM	0.95 (0.63, 1.43)	1.01 (0.82, 1.25)	0.96 (0.77, 1.18)	0.95 (0.67, 1.34)
Trauma	0.83 (0.61, 1.14)	0.90 (0.76, 1.07)	0.94 (0.79, 1.11)	0.99 (0.75, 1.31)
Tumour	1.02 (0.62, 1.66)	0.85 (0.65, 1.11)	1.07 (0.84, 1.40)	1.11 (0.73, 1.70)
Infection	0.69 (0.48, 1.00)	**0.74 (0.60, 0.93)***	1.04 (0.84, 1.29)	0.87 (0.65, 1.17)
Other	0.88 (0.62, 1.26)	**0.76 (0.60, 0.95)***	1.07 (0.88, 1.29)	0.94 (0.71, 1.26)
Comorbidities				
IHD	**0.71 (0.57, 0.89)** **	0.99 (0.91, 1.07)	1.04 (0.96, 1.14)	0.94 (0.82, 1.07)
PVD	0.96 (0.81, 1.14)	0.99 (0.90, 1.08)	0.96 (0.87, 1.06)	0.93 (0.79, 1.08)
DM	0.96 (0.65, 1.41)	0.82 (0.67, 1.01)	1.04 (0.86, 1.27)	1.00 (0.74, 1.36)
Complications				
Wound Breakdown	**1.59 (1.30, 1.93)*** **	1.26 (1.05, 1.52)	**1.17 (1.02, 1.33)***	**1.31 (1.11, 1.54)** **
Transtibial	-	-	1.14 (1.00, 1.31)	**-**
Transfemoral	-	-	**1.47 (1.24, 1.76)*** **	**-**
Bilateral	-	-	**1.90 (1.39, 2.60)*** **	**-**
Other Illness	0.91 (0.70, 1.17)	**1.10 (1.00, 1.20)***	**1.30 (1.17, 1.43)*** **	**1.19 (1.01, 1.41)***
Stump skin problem	0.89 (0.73, 1.09)	0.97 (0.87, 1.07)	**1.21 (1.09, 1.35)*** **	1.01 (0.85, 1.20)
Fall	1.20 (0.74, 1.95)	0.99 (0.86, 1.14)	1.08 (0.93, 1.26)	-
40 years old	-	-	-	**2.33 (1.23, 4.41)** **
65 years old	-	-	-	**1.35 (1.06, 1.71)***
90 years old	-	-	-	0.93 (0.64, 1.37)
Medically Unstable	0.74 (0.39, 1.45)	0.93 (0.64, 1.34)	1.40 (0.70, 2.80)	1.63 (0.63, 4.22)
Problem other foot	0.89 (0.69, 1.13)	1.02 (0.90, 1.15)	1.21 (1.05, 1.39)	-
1996	-	-	-	**0.58 (0.36, 0.94)***
2002	-	-	-	0.85 (0.66, 1.10)
2010	-	-	-	1.42 (1.01, 1.99)
Stump pain	-	-	0.87 (0.64, 1.17)	1.21 (0.77, 1.92)

Each variable adjusted for all other co variables in table
* p<0.05, **p<0.01, ***p<0.001
~ IPP introduced in 1998, # RRD introduced in 2000