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ORIGINAL REPORT

ABILITY TO RETURN TO DRIVING AFTER MAJOR LOWER LIMB AMPUTATION

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Objective: **The aims of this study were to examine the ability of patients to return to driving cars and riding motorcycles after lower limb amputation, and to explore the factors that significantly affect such ability.**

Design: **A sample of 90 participants, mean age 55.2 years (standard deviation 12.5), were recruited from a tertiary hospital. Inclusion criteria were: age over 18 years; unilateral or bilateral major lower limb amputation; and having been driving cars and/or riding motorcycles 6 months prior to amputation. Data collected via a structured questionnaire revealed that the most common cause of amputation was diabetic foot complications (75.6%).**

Results: **Nearly half (45.6%) of the participants returned to driving/riding within 1–72 months post-amputation. Males ($p < 0.05$) and those wearing prostheses ($p < 0.001$) significantly returned to driving/riding. The main reasons for not driving/riding were family members' concerns, other medical illnesses, and lack of confidence of the patient.**

Conclusion: **The rate of return to driving/riding among patients with lower limb amputation is low. Clinicians should address family members' concerns and patient's level of confidence in their rehabilitation services.**

Key words: automobile; driving; automobile driver examination; rehabilitation; physical disability.

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INTRODUCTION

Employment, recreation and community life are usually affected after lower limb amputation (1). For people with disabilities, the ability to drive is important as it can assist social reintegration and optimize independence. Improving mobility in people with amputation can also enhance successful integration in employment (2). Therefore, the ability to return to driving/riding after a major limb amputation is an important goal for rehabilitation, as this allows patients to achieve functional independence, as well as enabling them to resume work and leisure activities.

Previous studies conducted in Western countries have reported that up to 70–80% of people who had undergone lower limb amputation were able to return to driving (3, 4). Factors such as gender (being female), age (more than 60 years old), right-sided amputation and pre-amputation driving frequency reduce the likelihood of return to driving (4), whilst use of prosthesis, aetiology of amputation, side of amputation and level of amputation have no influence on driving ability (5). The appropriate types of vehicle modification and driving techniques for lower limb amputee drivers are unclear; many subjects returned to driving without any vehicle modifications and used their prosthetic legs to operate the foot pedals while driving (3, 4).

As in most countries of the world, in Malaysia cars and motorcycles are the two most widely used modes of transport. These vehicles are used for both vocational and non-vocational purposes. The motorcycle, in particular, is an important mode of transport, especially for city dwellers and young people, due to the congested roads in large cities, as well as the low cost of the vehicle.

At present, it is not mandatory for medical practitioners in Malaysia to report to the licensing authority about persons with impairments that may affect their ability to drive. Drivers with an existing driving license who became disabled and who wish to continue driving are required to declare their disability to the licensing authority and apply for a disabled driving license. Based on the assessment of the licensing authority, the subjects may or may not need a fitness to drive assessment by a government doctor. The doctors, based on their own opinion, are expected to comment on the person's ability to drive safely, and make recommendations about driving techniques and types of vehicle modifications. In some hospitals, a detailed driving assessment can be made by a trained occupational therapist. There has been growing interest in disabled driving in Malaysia, and various projects have been initiated to improve the currently available service.

There is little information available about disabled driving in Malaysia. We provide guidance on driving to our patients based on our own opinion rather than using scientific evidence. Driving is affected by laws and regulations that exist in any particular country and therefore it is pertinent that we have our own local data. The data will facilitate the development of services for the disabled population returning to drive in this region.

The aims of this cross-sectional study were to analyse the rate of return to driving after major lower limb amputation and

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to explore the factors that influence it. We also describe the techniques used for driving, the types of vehicle modifications, and identify barriers that prevent return to driving.

METHODS

Study design and setting

This was a cross-sectional, single centre study using a questionnaire to survey patients who returned to driving cars and riding motorcycles after major limb amputation in a tertiary hospital. Approval was obtained from the University Malaya Medical Centre medical ethics committee prior to the study.

Participants

Patients who attended the amputee rehabilitation clinic were screened for study inclusion. Inclusion criteria were: age over 18 years, with unilateral or bilateral amputation of major lower limb(s) (this includes hip disarticulation, transfemoral, knee disarticulation or transtibial) and active automobile driver (driving cars and/or riding motorcycles) within 6 months prior to amputation. Patients with physical disabilities other than acquired lower limb amputation (hemiplegia, upper limb amputation or abnormality, congenital lower limb amputation) and cognitive impairment were excluded from the study. Data were collected between February 2010 and July 2010. On average, 50 patients attend the clinic monthly, of whom 8–10 are new patients.

Data collection

Data were collected using a self-constructed questionnaire. The questionnaire was specifically designed, taking into consideration the aims and objectives of this study. It consisted of 3 parts: the first part explored demographic data and clinical characteristics, the second part looked into participants' driving/riding habits pre- and post-amputation, the type of motor vehicle/motorcycle used, frequency of driving and type of modification made to enable driving/riding, and the third part consisted of a list of 12 barriers that could have prevented participants from driving/riding. These barriers were identified from previous literature (3, 4) and one open-ended option to capture other reasons. A pilot study was conducted on 15 patients, and necessary amendments were made to the instrument.

The principal investigator administered the questionnaire personally (via face-to-face interviews); consent was obtained from the participants prior to the interviews. Each participant was informed of the objectives, confidentiality and voluntary nature of participation in the study. The average length of time for each interview was 20 min.

Ninety participants (including the initial 15 patients in the pilot study) were included. Two participants declined to participate due to time constraints.

Statistical analysis

The data were analysed using the computer program Statistical Package for Social Studies (SPSS) version 17. Descriptive statistics were used to describe the demographic characteristics and the barriers or obstacles to driving/riding. The statistical significance between groups (e.g. gender, level of amputation, right/left amputation, and unilateral /bilateral amputation with return to driving) was evaluated using χ^2 analysis. Multiple logistic regression was performed on all patients to determine the predictors of return to driving post-amputation. Patient's characteristics, pre-driving factors, as well as reasons for not driving, were included as predictors.

RESULTS

Sample characteristics

The clinical characteristics data of the sample are described in Table I. The mean age and standard deviation (SD) at the time of interview was 55.2 years (SD 12.5). The youngest participant was 21 years old and the oldest 79 years old. The mean age at amputation was 51.3 years (SD 13.2). The mean duration since amputation was 3.8 years (SD 4.8) (range: 1 month to 25 years). The male to female ratio was approximately 6.5:1 (78 males, 12 females).

Table I. *Clinical characteristics of participants (*n = *90)*

Characteristics	*n* (%)
Type of amputation	
Right transtibial	35 (38.9)
Left transtibial	26 (28.9)
Right transfemoral	11 (12.2)
Left transfemoral	7 (7.8)
Bilateral transfemoral	1 (1.1)
Bilateral transtibial	9 (10.0)
Right transtibial and left transfemoral	1 (1.1)
Reasons for amputation	
Diabetic foot complication	68 (75.5)
Peripheral vascular disease	6 (6.7)
Trauma	15 (16.7)
Tumour	1 (1.1)
Prostheses wear post-amputation	
Yes	59 (65.6)
No	31 (34.4)

Rates of return to driving

Prior to amputation, 46 (51.1%) participants were driving/riding both cars and motorcycles, 27 (30%) drove cars only, and 17 (18.9%) rode motorcycles only. The majority of the participants drove cars (83.5%) and rode motorcycles (79.3%) daily. The mean duration of car driving and motorcycle riding prior to amputation was 26.2 (SD 7.2) and 22.0 (SD 17.6) years, respectively.

Of the 90 participants surveyed, 41 (45.6%) returned to driving/riding post-amputation. The median time was 6 months (range: 1–72 months). However, two participants stopped driving later due to another leg amputation and poor vision. The 3 main reasons for returning to driving/riding were non-vocational activities (65.8%), followed by need to return to work (19.5%), and hospital visits (12.1%).

Of the 32 participants who resumed driving post-amputation, 15 had right-sided amputation, 14 participants had left-sided amputation, and 3 participants had bilateral amputation. For those who resumed riding motorcycle post-amputation; 10 participants had right-sided amputation, 8 had left-sided amputation, and 1 had bilateral amputation.

Factors influencing return to driving/riding

Men were significantly more likely to return to driving/riding compared with women ($p < 0.05$). Half (39/78) of the male participants returned to driving/riding, compared with 16.6% (2/12) of the females. Participants who wore prostheses (37/41) were also significantly more likely to return to driving/riding compared with those who did not ($p < 0.001$). Age, type, side, level and aetiology of amputation, and pre-amputation driving frequency were not significantly associated with return to driving/riding (Table II).

Table II. *Factors influencing return to driving/riding post-amputation*

	Drivers (n=41) n	Non-drivers (n=49) n	Significance (χ^2) p
Gender			0.031*
Male	39	39	
Female	2	10	
Reason for amputation			0.630
Diabetic	30	38	
Non-diabetic	11	11	
Type of amputation			0.771
Unilateral	36	7	
Bilateral	5	7	
Unilateral side			0.450
Right	20	26	
Left	17	16	
Level of amputation			0.363
TTA	34	36	
TFA	7	12	
Prosthesis wear			0.001*
Yes	37	22	
No	4	27	
Car driving frequency			0.602
Pre-amputation			
>5 days/week	28	33	
<5 days/week	6	7	
Motorcycle riding			
Frequency pre-amputation			0.496
>5 days/week	25	26	
<5 days/week	5	8	

*p<0.05.
TTA: transtibial amputation; TFA: transfemoral amputation.

Table III. *Comparison of driving/riding habits pre- and post-amputation,* n = *41*

	Pre-amputation n (%)	Post-amputation n (%)
Type of vehicle		
Car only	11 (26.8)	22 (53.7)
Motorcycle only	7 (17.1)	9 (21.9)
Both	23 (56.1)	10 (24.4)
Frequency of driving		
Car		
>5 days/week	28 (68.3)	18 (43.9)
<5 days/week	6 (14.6)	14 (34.1)
Motorcycle		
>5 days/week	25 (61.0)	16 (39.0)
<5 days/week	5 (12.2)	3 (7.3)
Car type		
Manual	18 (43.9)	5 (12.1)
Automatic	9 (22.0)	24 (58.5)
Both	7 (17.1)	3 (7.3)
Motorcycle type		
Standard	30 (73.2)	16 (39.0)
Automatic/scooter	0 (0.0)	3 (7.3)

Driving habits

There were changes in driving habits post-amputation in terms of the type of vehicle and frequency of driving. Table III presents the comparison of driving habits pre- and post-amputation for those who resumed driving/riding. Nearly half (11/23) of the participants who previously drove/rode both cars and motorcycles switched to driving cars only after the amputation. In addition, most (13/18) of the participants who drove cars with manual transmission, switched to automatic transmission. Among those who rode only motorcycles prior to amputation, 36.6% (11/30) switched to driving cars only post-amputation. Although the frequency of driving/riding was reduced following the amputation, it was not statistically significant.

Vehicle modification and driving technique/style

Types of vehicles, driving techniques and vehicle modification in relation to type of amputation are listed in Table IV. Except for two, participants who drove cars following the amputation did not have any car modification for driving. The types of car modification carried out by the two participants were left-sided accelerators and hand controls. Most of those who rode motorcycles also did not have any vehicle modification.

Table IV. *Types of vehicles and modifications among those who return to driving/riding*

	Right TTA (n=17)	Left TTA (n=13)	Right TFA (n=3)	Left TFA (n=4)	Bilateral TTA (n=4)
Type of motor vehicle, n (%)					
Car only	8 (19.5)	7 (17.0)	2 (4.8)	2 (4.8)	3 (7.3)
Motorcycle only	5 (12.1)	2 (4.8)	0 (0.0)	1 (2.4)	1 (2.4)
Both	4 (9.7)	4 (9.7)	1 (2.4)	1 (2.4)	0 (0.0)
Type of car, n					
Automatic	7	9	3	3	2
Manual	3	2	0	0	0
Both	2	0	0	0	1
Type of motorcycle, n					
Standard	7	5	1	2	1
Automatic/scooter	2	1	0	0	0
Modification, n (%)					
Car	2 (6.25)	0 (0)	0 (0)	0 (0)	0 (0)
Left-sided accelerator	1 of 2				
Hand control	1 of 2				
Motorcycle, n (%)	3 (15.7)	1 (5.2)	1 (5.2)	1 (5.2)	1 (5.2)
Tricycle	3 of 7	1 of 7	1 of 7	1 of 7	1 of 7

TTA: transtibial amputation; TFA: transfemoral amputation.

Table V. *Driving techniques: side of foot preference to operate car pedals among car drivers*

Side of foot	Right TTA (n=12) n	Left TTA (n=11) n	Right TFA (n=3) n	Left TFA (n=3) n	Bilateral TTA (n=3) n
Accelerator foot					
Left	5	0	2	0	0
Right	7	11	0	3	2
Both	0	0	1	0	1
Brake foot					
Left	6	0	3	0	1
Right	4	11	0	3	2
Both	2	0	0	0	0

TTA: transtibial amputation; TFA: transfemoral amputation.

In terms of driving techniques (Table V), 6 out of 15 right-sided amputation participants continued to drive using a left-foot driving style (using only their left foot to control the pedals). Some participants were able to drive using a two-footed driving technique (using either foot to control pedals), implicating that they used their prosthesis to control the pedals. As expected, those with left-sided amputation did not need to change their driving style as they continued to use the right leg to control the pedals.

Barriers

Participants (49/90) who did not resume driving/riding after amputation were asked to select from the list provided the 3 most important factors that prevented them from driving/riding. The results are shown in Table VI. The 3 most significant reasons as pointed out by the patients were: (*i*) prohibited by family members from driving (32.2%); (*ii*) medical health reason, e.g. poor vision, stroke (28.9%); and (*iii*) fear and lack of confidence to drive (21.1%).

Predictors of return to driving

Two predictors were found to be significant; age of the patients and prosthetic restoration. The overall correct classification rate was 73.3%. Patients over 60 years of age are 4 times more likely not to return to drive after amputation compared with those under 60 years of age (p=0.009, 95% confidence interval (CI) 1.43–11.56). Patients who had prosthetic restoration are 12 times less likely not to return to drive compared with patients who did not have prosthetic restoration (p=0.000, 95% CI 0.024–0.282).

Table VI. *Barriers to return to driving car and riding motorcycle*

Factors	%
1. Told by family member not to drive	32.20
2. Medical health reasons (including poor vision, stroke)	28.90
3. Fear and lack of confidence to drive	21.10
4. Others unspecified reasons	20.00
5. Too early after amputation to drive	12.20
6. No prostheses	8.90
7. Prefer not to drive	8.90
8. Unable to do car and motorcycle modification	8.90
9. Financial reasons	8.90
10. No access to car and motorcycle	4.40
11. Prefer to use public transport	3.30
12. No facilities to learn driving/riding post-amputation	3.30

DISCUSSION

This study found that 45.6% of participants returned to driving/riding after amputation. The rate of return to driving was much lower than that reported by Boulias et al. (80.5%) (4). The difference is probably due to the sample selection; we included all patients regardless of their prosthesis status, while Boulias et al. selected only those who were already prosthetically restored for at least one year. Successful prosthetic users are no doubt more functional, and this would have contributed to the high rate of return to driving.

This study has shown that gender and prosthesis wear were the two factors that were significantly associated with return to driving/riding. Males were more likely to return to driving following amputation compared with females; and this finding is supported by reports from two previous studies (4, 5). In Malaysia, men are usually the main wage earner in the family and also are more likely to have an active role in the community. Hence, resuming driving/riding is essential for them to continue with these roles. We also found that prosthesis wear is a significant influence in returning to driving/riding. This is probably due to the fact that wearing prostheses enables the participants to control the pedals. A previous study (5) did not find this association, probably due to a different sample.

We expected those with left-sided amputations to be more likely to return to driving compared with those with right-sided amputations, as the right leg is commonly used to operate foot pedals. Even though data showed that the percentage of left-side amputees was higher compared with right-side amputees (51.5% vs 43.4%), it was not statistically significant. Moreover, participants with transtibial amputation are more likely to return to driving/riding compared with those with transfemoral amputation (48.5 % vs 36.8%). However, this was again not statistically significant. As found in other studies, the aetiology of amputation, type of vehicles and driving frequency pre-amputation did not influence return to driving/riding (4, 5).

Car modifications and driving techniques for disabled people remain unclear. Tachakra (6) suggested that those with left leg disability driving manual cars and those with right leg disability driving either manual or automatic cars should consider modifications. The suggested modifications are left-foot driving style, change of side of the pedals from right to the left side and using hand-controlled accelerators and brakes. Many of our participants opted not to have any vehicle modification. This pattern was also observed in two other studies (3, 7); up to 80% of disabled persons continued to drive without any vehicle modification for easier driving control. Even though, vehicle modification services are readily available here, the financing is not provided by the government and the procedures are rather lengthy. Looking at the factors listed to prevent return to

driving (Table VI), vehicles modification was not considered a major barrier. We postulated that this behaviour resulted from the patients' own perception of their driving ability; they are unlikely to follow our advice to modify their vehicle as they feel they can drive without doing so.

We routinely advised patients not to use prostheses to operate accelerator/brake pedals, as this might give rise to problems such as the inability to control pedal pressure, difficulty in switching between pedals and delayed pedal reaction time. Despite this, a third of those with right-sided amputation continued to drive manual transmission cars, using the prosthesis to control the accelerator pedal. It is interesting to note that right-sided amputees who continued to use prostheses to operate the accelerator and foot pedals have similar pedal response times compared with those operating a left-sided accelerator with the normal left foot (8). The left-foot driving style did not have a delayed pedal reaction time and the two-footed technique was not to be recommended as it had the slowest reaction time (8). The limitation of using prostheses to control the pedals is that the patients might have difficulty driving if there is problem with their prostheses, including pain with their prosthetic leg (9).

There is little literature regarding return to riding a motorcycle after lower limb amputation. In developed countries, motorcycle riding is considered as a recreational activity rather than a means of transport, contrary to the situation in developing countries (10). When patients want to ride motorcycle following lower limb amputation, we advised them to add two extra wheels to their existing motorcycles. This modification provides stability to the vehicle; riders need not use their legs to stabilize the bike while idling. Rates of return to riding motorcycles as a group is 30%, compared with 43% for return to driving cars. We expected the return rate to be higher, as only minimal modification is needed and it is also cheaper compared with car modifications. The lower rate for motorcycles is probably due to the fact that it is possible for the amputees to drive cars without any modification and in addition, the car is felt to be more stable and safer compared with the motorcycle.

More than half (54.4%) of the participants in our study did not return to driving/riding. One-third of them were prevented from driving by concerned family members. This is in contrast to the situation in Western countries, where the researchers find it interesting if their study reveals a patient being prevented from driving by the family (4). This information implies that, in the local context, family members play an important role in decision-making and should be included when discussing return to driving. It is not surprising that medical conditions are identified as the second most common barriers in this study. The majority (75%) of the participants required amputation as the result of diabetic complications. Fear and lack of confidence of patients were also common. Therefore it seems that the common barriers are not directly related to their amputation. Driving assessment and recommendations about vehicle modifications for the disabled patients are not enough, and routine counselling for patients' family members should routinely be offered. The findings from this study clearly state the need to for this.

As far as limitations are concerned, this study involved only 1 centre and thus, there would be some selection bias with respect to the type of patients seen in a tertiary hospital and also the bias of a convenient sampling method. We are unable to ascertain that the study population is representative of the general amputee population, as there is no previous epidemiological study on amputee population in Malaysia. As such, it is important to extend this study to other hospitals that offer rehabilitation services; the results of a multicentre qualitative study offer more generalization. This study did not include patients who wish to return to driving after the amputation but cannot do so for various reasons. Including such segments could have enriched this study to portray a more representative scenario.

In conclusion, this study shows that the rate of return to driving/riding following lower limb amputation is low among amputees in Malaysia. Barriers such as family understanding/support and lack of confidence, as well as confusion over various driving adaptations and vehicle modifications, should be addressed during rehabilitation.

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