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The quality of life analysis of knee prosthesis with complete microprocessor control in trans-femoral amputees

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A B S T R A C T

Objective: The aim of this study was to analyze the patient demographics, etiology of limb loss as well as reporting SF-36 scores for microprocessor prosthesis users in Turkish population.
Methods: We reviewed 72 patients (61 male and 11 female; mean age: 37.7 ± 10.7) with uni-lateral, above knee amputation and a history of regular and microprocessor prosthesis use. All patients were called back for a last follow-up and they were asked to fill a self-administered general health status questionnaire (SF-36).
Results: According to the SF-36 results; physical component score (PCS) score was 46 ± 7.3 and mental components summary (MCS) score was 46.5 ± 9.1. These scores have statistical similarity with Turkish healthy controls, except SF (social functioning) sub-dimension. PCS score for women microprocessor users were significantly lower than men (43.3 vs. 48.7, $p = 0.03$), but MCS scores were similar in between genders (46 vs. 48.2, $p = 0.13$). Conventional prostheses usage time was positively correlated with physical function (PF) scores ($r = 0.322$, $p = 0.010$). Microprocessor prosthesis usage time was negatively correlated with role limitations due to emotional problem (RE) scores ($r = -0{,}313$, $p = 0.009$).
Conclusion: The quality of life surveys were showed that the loss of an extremity have higher physical and psychological impact on women's physical scores. Overall, SF-36 results were similar in microprocessor using amputee's and Turkish normal controls.
Level of evidence: Level IV, therapeutic study.

Introduction

The high-energy cost of ambulation is a major concern for trans-femoral prostheses wearers.[1] The microprocessor prosthesis appears to offer the amputee greater function and safety. Metabolic energy consumption is lower than regular prosthetic designs.[2] Several different electronic controlled prosthesis designs have been put on the market in the past decade. Some designs are able to control both stance and swing phase, whereas some can only control the swing phase.

The angle sensors detect the angle of joints. Information is then sent to the microprocessor and the patients are able to walk more naturally with joints adapting faster and more accurately. Stance phase controls the resistance automatically when there is a tendency for the knee to buckle. Swing control allows for adequate resistance to be applied during heel rise, allowing knee flexion and appropriate toe clearance. Swing control also applies during and mimics the eccentric contraction of the anatomical hamstrings and gluteus maximus. Benefits include shock absorption, restoration of sinusoidal pattern of gait cycle, energy efficiency and an overall more natural gait pattern. Hip and lower back stress will also be minimized.[3]

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When using a microprocessor controlled knee joint during walking, improved gait symmetry, a physiologic motion and load pattern on the prosthetic side, and load reduction on the contralateral side have been reported.[4–6] The risk of fall is reduced with using microprocessor prosthesis.[7] The success of prosthesis integration to the amputee's body encourages greater participation in normal public activities and improves physical and mental health status.[1,8]

In the recent literature, quality of life surveys that are specific to amputees are available but have not been widely published. The purpose of this study is to analyze the patient demographics, etiology of limb loss as well as reporting SF-36 scores for microprocessor prosthesis users in Turkish population.

Methods

This is a retrospective review of all microprocessor prosthesis users at a single center. Our clinic is one of the few centers that is competent for coordinating microprocessor prosthesis reports which is accepted and reimbursed by Turkish Social Security Institution. Study was approved by Institutional Review Board (IRB). All patients had above knee amputation at a single institution from 1995 to 2013 and a history of regular mechanic and microprocessor prosthesis use for varied times. Patients who were admitted to call back at the time of study were included and patients who have less than 6 months of microprocessor prosthesis use were excluded. Charts were evaluated for clinical and radiographical features. Collected data's were demographics, preamputation mobilization status, etiology of limb loss, comorbidities, time of regular (conventional) and microprocessor prosthesis use. Plain antero-posterior (AP) x-ray of stump was evaluated for the length of residual femur, bone spurs and hip joint degenerative changes. All prosthetic alignments and adjustments were performed by a qualified and experienced prosthetics.

All patients were called back for a last follow-up and they were asked to fill a self-administered general health status questionnaire (SF-36), which takes approximately 5–10 min. The SF-36 health survey (Quality Metrics, Lincoln, RI) is easy to use, acceptable to patients, and has established reliability and validity for many populations with impairments.[9] Turkish version was used for many disorders and healthy population in recent.[9–12] The SF-36 health survey (Quality Metrics, Lincoln, RI) has two main component scores, physical component score (PCS) and the mental component score (MCS). There are also eight sub-dimensions of SF-36 including physical functioning (PF), role limitations due to physical problems (RP), pain (P), general health perception (GH), mental health (MH), role limitations due to emotional problems (RE), vitality (V) and social functioning (SF) were evaluated individually (Table 1). The reliability coefficient of the SF-36 ranged from 0.60 to 0.94 and the test-retest reliabilities ranged from 0.60–0.81.[13] The outcomes of the questionnaire were used to compare perceived quality of life using the microprocessor prosthesis versus healthy controls reported in the literature.[9–12]

Statistical analysis

Statistical analysis was carried out using descriptive statistics (mean, standard deviation, frequency) for demographics, student t-test for parametric data, the Mann Whitney U (Wilcoxon rank test) test for non-parametric data and the chi-squared test for categorical data as appropriate. A p value of ≤ 0.05 was considered significant.

Results

Seventy-two patients (61 male, 11 female) were included in this study. All amputations were uni-lateral and above knee. The mean age of the patients at the time of study was 37.7 ± 10.7 and the mean age at amputation was 19.5 ± 11.3 years. The reason for amputation was traumatic in 56 (77%) and non-traumatic (congenital deformities, malignant tumors around the knee, vascular pathologies such as Buerger disease or infected knee arthroplasy) in 16 (23%) patients. The average duration of regular (conventional) prosthesis usage was 225.7 ± 151.9 months (median 183 months), and the average microprocessor prosthesis usage was 12.1 ± 5.8 months. All microprocessor were K4 type prosthesis. Radiological assessment showed that the mean stump (femur) length was 268.3 ± 59.5 cm long. Abductor muscle attachments were protected but adductor attachments were sacrificed and deattached to the end of bony stump two patients were underwent the removal of bone spur excision, which caused pain at the most distal part of stump. At final radiological control 1 patient had groin pain due to degenerative hip joint changes.

Patients were called back for a last follow up. According to the SF-36 general health status questionnaire, physical component score (PCS) score was 46 ± 7.3 and mental components summary (MCS) score was 46.5 ± 9.1. These scores have statistical similarity with Turkish healthy controls (MCS-TR; 47.7 ± 7.4, MCS-microprocessor; 46.5 ± 9.1, $p = 0.61$/PCS-TR; 48.1 ± 6.9, PCS-microprocessor; 46 ± 7.3, $p = 0.14$). Except SF (social functioning) sub-dimension of SF-36 (75.1 ± 19.6 vs. 90.5 ± 12.8, $p < 0.01$), all the others showed no significant differences between microprocessor using amputee's and Turkish normal controls (Tables 2 and 3).

PCS score for women microprocessor users were significantly lower than men (43.3 vs. 48.7, $p = 0.03$). MCS scores were similar in between genders (46 vs. 48.2, $p = 0.13$) (Table 4). SF-36 scores showed no differences between the patients who were amputated younger and older than 18 years old, an also between traumatic and

Table 1
SF-36 sub-dimensions and explanations.

SF-36 sub-dimensions	Low score	High score
Physical function	Limitation in all physical activity like dressing or taking a bath	Able to do all physical activities without limitation
Limitation of physical function	Role limitations in work and daily activities due to physical health problems	No physical limitation in work and daily activities
Pain	Severe and limiting pain	Painless or no limitation due to pain
General health perception	Believing in having a bad or worse health	Believing in having an excellent health
Mental health	Emotion of being nervous or in depression constantly	Emotion of being calm, relax and happy
Limitation of emotion	Role limitations in work and daily activities due to emotional problems	No limitation in work and daily activities due to emotional problems
Vitality	Feeling tired and exhausted	Feeling lively and energetic
Social function	Limitations in social activities due to physical and emotional problems	No limitation in social activities due to physical and emotional problems

Table 2
Mean (SD) scores for eight variables of SF-36 for women and men for Turkish population.[12].

Variables (N)	Women (n = 670) Mean ± SD	Men (n = 609) Mean ± SD
PF (1279)	80.6 ± 21.7	87.2 ± 17.1
RP (1279)	82.9 ± 28.6	89.8 ± 19.3
BP (1279)	81.0 ± 20.2	85.1 ± 16.4
GH (1279)	69.1 ± 16.9	73.6 ± 14.9
VT (1271)	63.4 ± 13.7	65.7 ± 11.9
SF (1279)	90.1 ± 12.9	91.7 ± 12.8
RE (1279)	89.0 ± 22.5	92.8 ± 15.1
MH (1271)	70.1 ± 11.4	71.0 ± 10.6
PCS (1271)	46.6 ± 9.9	49.4 ± 7.4
MCS (1271)	47.3 ± 9.8	48.2 ± 9.1

Table 4
Comparison of PCS and MCS scores between genders in microprocessor user amputee's.

	Women	Men	p Value
PCS	43.3	48.7	0.03
MCS	46	48.2	0.13

Table 5
Comparison of SF-36 scores regarding to the amputation age.

	Amputation < 18 years old	Amputation > 18 years old	p Value
SF-36	89.3 ± 7.3	86.6 ± 7.1	0.25

non-traumatic amputations respectively ($p = 0.25$, $p = 0.33$) (Tables 5 and 6).

Conventional prostheses usage time was positively correlated with physical function (PF) scores ($r = 0.322$, $p = 0.010$). Microprocessor prosthesis usage time was negatively correlated with role limitations due to emotional problem (RE) scores ($r = -0{,}313$, $p = 0.009$).

Table 6
Comparison of SF-36 scores regarding to the etiology of amputa.

	Traumatic etiology of amputation	Non- traumatic etiology of amputation	P Value
SF-36	90.4 ± 8.8	87.5 ± 6.2	0.33

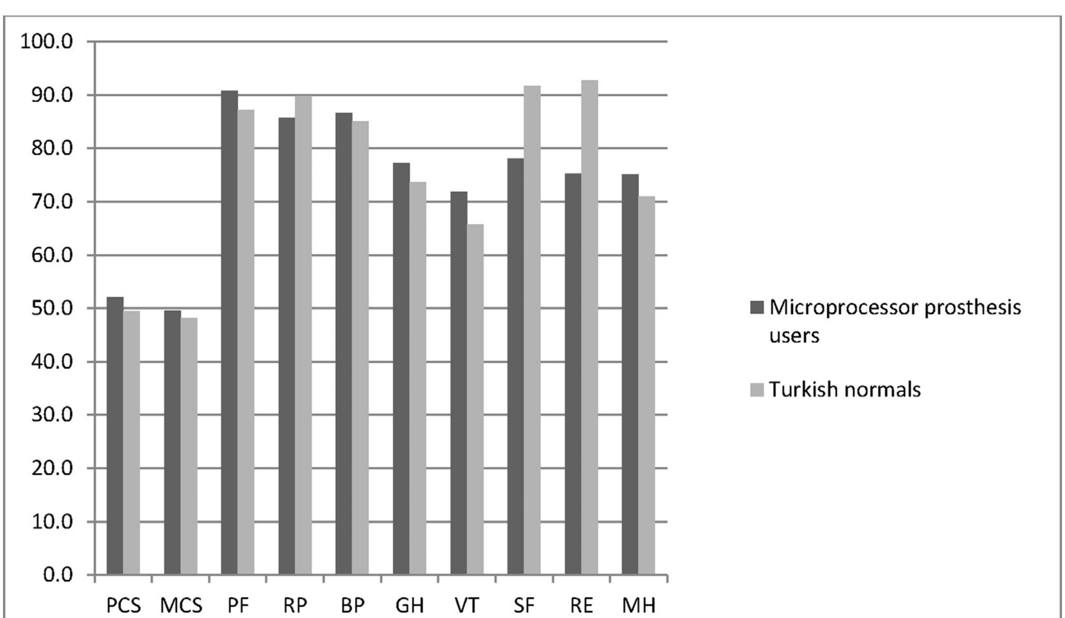
Discussion

In the last decades, a number of different electronic control prosthetic knee joints have been integrated with different new functions to improve gait symmetry and decrease metabolic energy consumption.[2,5,6] To date, quality of life surveys that are specific amputees are available but have not been widely used in recent studies. Our aim was to analyze the patient demographics, etiology of limb loss as well as reporting SF-36 scores for microprocessor prosthesis users in Turkish population.

Effectivity of prosthetics is dependent on the reliability of different functions offered to the amputee in daily life.[4] Previous reports have also shown that the successful integration of the prosthesis into the amputee's body image encourages greater participation in normal public activities.[1,4,14] In addition to the technical design of the knee component, the prosthetic user's residual limb length and performance has a decisive influence on all types of movements, especially on fall avoidance.[4] In this study, the mean femur length was 268.3 ± 59.5 cm, that is slightly longer than half of an adult femur.[15] According to our findings protection of abductor muscles and re-attachment of adductor muscles to the end of bony stump may increase the performance of prosthetic users and their life quality.[7,16]

Microprocessor prostheses have been recommended to a broad spectrum of individuals with amputation who seek a prosthesis with better gait control, from the highly functional individual to those who are limited in independent ambulation.[1] Objective information comparing these prostheses will assist in answering the issues about indications, contraindications, and cost affectivity.[1,17]

Table 3
Differences between microprocessor using amputee's and Turkish normal controls for all sub-dimensions of SF-36. Only SF (social functioning) showed significant difference (78.1 ± 19.6 vs. 91.6 ± 12.8, $p < 0.001$).



Our study gives objective information about daily life quality of prosthetic users. After using microprocessor prosthesis a minimum of one year, general health status questionnaire scores showed statistically similar results between amputee's and Turkish healthy controls (MCS-TR; 47.7 ± 7.4, MCS-microprocessor; 46.5 ± 9.1, $p = 0.61$/PCS-TR; 48.1 ± 6.9, PCS-microprocessor; 46 ± 7.3, $p = 0.14$).

Chin et al.[16] found that, the walking speed was approximately the same; energy expenditure as reflected by oxygen consumption was 31.1% higher than controls at the speeds of 50 m/min. They also found that the differences between controls and those with a transfemoral amputation persist when energy expenditure is expressed as oxygen cost per meter walked (ml/kg.m). Metabolic energy and oxygen consumptions are shown to be lower than regular prosthetic designs.[2] Due to lower energy expenditure, the quality of daily life may increase with microprocessor prosthetic designs. Energy expenditure may also differ depending on the cause of amputation. Oxygen consumption of above knee amputations due to vascular compromise was higher than traumatic causes.[18]

The differences in PCS score for women and men microprocessor users were significant in this study group (43.3 vs. 58.7, $p = 0.03$). Prosthesis users also showed lower SF (social functioning) scores than Turkish health controls (75.1 ± 19.6 vs. 90.5 ± 12.8, $p < 0.01$). These results may be related to their body appearance, psychological impact of the traumatic event and amputation process.

The limitations of this study were the differences in age, sex, educational status, types of injury and functional capacity between the patients that prevent the formation of homogeneous groups and decrease the power of comparative analyses. Since the microprocessor prosthesis was the current prosthesis of choice in this group of patient, SF-36 data were not analyzed for use of the regular, non-mechanic prostheses.

In conclusion, the quality of life surveys were showed that the loss of an extremity have higher physical and psychological impact on women's physical scores. According to the SF-36 results; except SF (social functioning) sub-dimension, all the others showed no significant differences between microprocessor using amputee's and Turkish normal controls. The patients are able to walk more naturally and spend less energy with stance – swing phase controlled microprocessor prosthetic designs.

Conflicts of interest

All authors declare that they have no conflict of interest. . This research received no specific grants from any funding agency in the public, commercial, or not-for-profit sectors. Each author certifies that he or she has no commercial associations that might pose a conflict of interest in connection with the submitted article.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This is an IRB approved prospective review.

Informed consent

Informed consent was obtained from all individual participants included in the study.

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