Osseointegration may improve function for people with poor outcomes in a traditional transfemoral socket

Ashley Carvalho, MPO carvalhoash6@gmail.com
University of Washington, Division of Prosthetics and Orthotics

Clinical Question: Does osseointegration improve functional outcomes compared to conventional socket systems in people with transfemoral amputation who have experienced poor outcomes?

Background: The connection between a person with amputation and their prosthesis is a key component of prosthetic fit and function. Traditionally, the prosthetic socket serves this purpose, however, many people with amputation experience socket-related residual limb problems that limit prosthetic wear-time, quality of life, and function.[1] One proposed solution to address these problems is direct attachment of the external prosthesis to the residual bone through osseointegration (OI).[2] Because the external prosthesis is directly connected to the body, OI removes the socket from the fitting and functioning equation with the goal of improving use, function, and quality of life of the individual. However, due to the invasive and experimental nature of OI, it is important for prosthetists and researchers to carefully examine possible benefits and risks associated with its use before integration into standard practice.[2] OI has occurred as early as 1942 on a small scale with custom implants, and varying degrees of success.[2] Work from teams led by Brånemark in Sweden and Al Muderis in Australia have resulted in established treatment and rehabilitation protocols, and improved quality of evidence available to the field.[1–3] In the short-term, studies have presented evidence of increased prosthetic use, mobility, functional status, and fewer problems in patients who have been treated with OI.[2,4] But it is yet to be seen whether these benefits are generalizable to a larger population, persist in the long-term, and outweigh potential risks such as infection and complications of long-term use.[2] According to the International Classification of Functioning, Disability and Health (ICF) model of disability, activity limitations following amputation and prosthesis-related complications have the ability to affect a person's overall quality of life and participation in their community. The purpose of this critically appraised topic is to synthesize current evidence on functional outcomes following OI compared to outcomes with conventional socket prostheses in persons with transfemoral amputation.

Search Strategy
Databases searched: PubMed, Web of Science, CINAHL
Search Terms: (Transfemoral OR "trans-femoral" OR "Above-Knee" OR "above knee" OR "AK") AND osseointegration AND function* AND artificial limb[MeSH Terms] ; TS=(Transfemoral) AND TS=(Osseointegration) AND TS=(Function*)
Eligibility criteria: Original research, peer-reviewed, published in last 10 years, English language, transfemoral amputation, comparison study, includes functional outcomes data.

Synthesis of Results: Four studies[5–8] including a range of 22-111 participants with transfemoral amputation compared functional outcomes from before and after osseointegration intervention. The most common reasons for amputation in all studies were trauma and tumor, and recruitment was based on a history of socket-related issues.[5–8] Three of the studies[5–7] used a prospective cohort design and one[8] used a prospective case series design to assess outcomes before and after the osseointegration procedure. Three different implants were used across the four studies, with two studies[5,6] exclusively using the OPRA implant. All four studies[5–8] reported significant improvements in Questionnaire for Persons with Transfemoral Amputation (Q-TFA) Global Score while one[5] reported significant increases in Q-TFA Mobility Scores and one reported significant increases in Physical Function sub scores of the SF-36.[6] Performance-based improvements in function were reported at 12-months[7,8] of follow-up in two studies using the TUG test and one study using the 6MWT.[8] There is strong agreement between studies regarding improvements in function, however, the quality of this evidence is low to moderate due to the limitations across studies. Key limitations included a relatively small sample size, the use of 3 different implants, and a lack of blinding in all studies, though it will be challenging for future studies to address these limitations due to the invasive nature of the OI intervention. In addition, two studies[5,6] used only self-report measures, and two studies[7,8] had a relatively short follow-up time of 12 months. Other important outcomes to consider are improvements in quality of life and risk of adverse events which were reported in all four studies.[5–8]

Clinical Message: Based on results from these studies, OI may be a viable option for improving functional outcomes for people with transfemoral amputation who have experienced socket-related issues limiting function. These findings should only be generalized to those with trauma, tumor, or stable vascular etiologies. Further study of potential long-term adverse effects and differences in performance across implants are needed to assess long-term efficacy and safety.

Osseointegration may improve function for people with poor outcomes in a traditional transfemoral socket

Ashley Carvalho, MPO carvalhoash6@gmail.com
University of Washington, Division of Prosthetics and Orthotics

	Hagberg, 2020[5]*	**Brånemark, 2019[6]***	**Leijendekkers, 2019[7]****	**Van de Meent, 2013[8]**
Population	n=111 (baseline);n=90 (2yr FU); n=67 (5yr FU); n=55 (7yr FU); n= 34 (10yr FU); n=14 (15yr FU) Etiology: The most common reasons for amputation were trauma (n=75) and tumor (n=23). Years post-amputation: not reported Inclusion Criteria: TF amputation, experiencing socket-related problems, mature and sufficient residual anatomy. Recruitment: referred to clinic if they met inclusion criteria between 1999 and 2017	n=51 (baseline) n=40 (5yr FU) Etiology: The most common reasons for amputation were trauma (n=33) and tumor (n=12). Years post-amputation: not reported Inclusion Criteria: TF amputation, experiencing socket-related problems, ages 20-70, likeliness for compliance, and non-vascular etiology. Recruitment: referred to clinic if they met inclusion criteria between 1999 and 2007	n=31 Etiology: n=17 (trauma) n=7 (tumor) n=3 (vascular) n=4 (other) Years post-amputation: range 1-46 years Inclusion Criteria: experiencing socket-related problems; etiology of trauma, tumor, stable vascular, or congenital; no cognitive impairment Recruitment: all patients treated with OI from 04/2014-03/2016	n=22 Etiology: n=20 (trauma) n=2 (tumor) Years post-amputation: range 2-45 years Inclusion Criteria: survey including questions regarding current prosthesis, prosthetic use, and QoL based on the Q-TFA Recruitment: referred to clinic for persistent socket-related issues that limited prosthetic use.
Study Design	Prospective Cohort Study	Prospective Cohort Study	Prospective Cohort Study	Prospective Case Series
Intervention	OPRA Implant(Integrum AB, Mölndal, Sweden): Three-part implant implanted during 2 procedures 6 months apart. Rehabilitation Program: progressive loading of the implant following 2nd procedure.	OPRA Implant (Integrum AB, Mölndal, Sweden): Three-part implant implanted during 2 procedures 6 months apart. Rehabilitation Program: progressive loading of the implant following 2nd procedure.	Integral Leg Prosthesis (Orthodynamics GmbH), Osseointegrated Prosthetic Limb(Permedica s.p.a): 2 procedures 6-8 weeks apart. Rehabilitation Program: Mean duration 24 weeks. Rehab started 1-week post 2nd procedure	Integral Leg Prosthesis (Orthodynamics GmbH): 2 procedures, 6-weeks apart. Same components as former prosthesis. Rehabilitation Program: Twice/week for 2 hours in group sessions. Average 6-8-week duration
Comparison	Traditional socket	Traditional socket	Traditional socket	Traditional socket
Duration of Follow-up	2-,5-,7-,10-, and 15-year FU	5-year FU	6- and 12-months FU	12-months FU
Sampling	Convenience	Convenience	Convenience	Convenience
Relevant Outcomes	Self-Report: Q-TFA Global Score; Q-TFA Mobility Score; MFCL (based on Q-TFA responses) Performance: not included	Self-Report: Q-TFA Global Score; SF-36 Physical Function, Role Physical, and Physical sub scores. Performance: not included	Self-Report: Q-TFA Global Score; Question about walking distance. Performance: TUG; 6MWT; MFCL; AMWAP; Hip abductor strength (Nm/Kg); use of assistive devices.	Self-Report: Q-TFA Global Score Performance: TUG, 6MWT

Osseointegration may improve function for people with poor outcomes in a traditional transfemoral socket

Ashley Carvalho, MPO carvalhoash6@gmail.com
University of Washington, Division of Prosthetics and Orthotics

	Hagberg, 2020[5]*	Brånemark, 2019[6]*	Leijendekkers, 2019[7]**	Van de Meent, 2013[8]
Key Findings	Self-Report: Q-TFA Prosthetic Mobility and Global Scores showed significant improvement at 2, 5, 7, and 10-year FU. Q-TFA global score improved significantly at 15-year FU. Activity grade (MFCL) improved significantly at 2, 5, 7, and 10-years FU. Performance: not included	Self-Report: Q-TFA Global and Mobility Scores improved significantly at 5-year FU (P<0.0001). Physical Function (P<0.0001), Role Physical (P=0.02), and Physical subscale (P<0.0001) scores of the SF-36 improved significantly at 5-year FU. Performance: not included	Self-Report: Q-TFA Global Score increased 22 points at 12-month FU (P<0.001**). Patient-reported walking distance increased 1350m at 12-month FU (P<0.001**). Performance: TUG times decreased by 1.7 seconds at 12-month FU (P=0.005**). 6MWT results did not increase significantly. Number of participants rated K3-4 increased from 17/31 at baseline to 26/31 at 12-month FU. Number of participants rated AMWAP grade E-F increased from 14/31 at baseline to 21/31 at 12-month FU. Hip abductor strength increased significantly on sound and residual limb side at 12-month FU by 0.17 and 0.18 respectively. The percentage of walkers without an assistive device increased by 30% outdoors and 23% indoors at 12-month FU**. All significant findings at 12-month FU were also significant at 6-month FU except for TUG**.	Self-Report: Q-TFA Global Score increased by 68% (P=0.001). Performance: TUG times decreased by 44% (P=0.002). 6MWT distance increased by 27% (P=0.002).
Limitations	Lack of control group. Small sample size (increased attrition at further FU). Only used self-report measures. Single-center design reduces generalizability. MFCL determined based on Q-TFA scores	Lack of control group. Small sample size (further limited by attrition). Only used self-report measures. Single-center design reduces generalizability.	Lack of control group. Small sample size (further limited by stratification). Lack of blinding of raters. Use of unvalidated single questions as outcomes.	Lack of control group. Small Sample size. Lack of blinding of raters. Q-TFA Prosthesis Use Score used differently than intended (hours/week). FU time of only 12-months.
Other Findings	55% of patients had at least 1 mechanical complication. Q-TFA Prosthesis Use and Problem Score significantly improved at 2-, 5-, 7-, and 10-year FU. A positive relationship between higher activity level and higher rate of implant mechanical failure was found.	Survival rate of implants was 92% and revision-free rate was 45% at 5-year FU. Q-TFA Prosthesis Use and Problem Scores significantly improved. 28/40 pts reported using their prosthesis every day ≥13hours/day.	Q-TFA Prosthesis Use Scores increased significantly at 12-month FU**. Mean Prosthetic comfort increased significantly from baseline. 19/31 transfemoral participants experienced no adverse events. 30/31 participants were satisfied with the global perceived effect of the BAP.	Q-TFA Prosthesis Use Score increased by 45%. O_2 consumption decreased by 18% following intervention. 8 participants reported minor soft tissues infections that did not make functional outcomes significantly different than average.

***Some baseline data, protocol, and setting for these studies are the same.**

****The study also included n=9 participants with transtibial amputation. Raw findings reported in this evidence table include outcomes for the n=31 participants with transfemoral amputation, with the exception of statistical findings only calculated for the combined group of n=40 transfemoral and transtibial participants. These instances will be clearly denoted with ** in the table.**

Q-TFA= Questionnaire for Persons with Transfemoral Amputation; MFCL= Medicare Functional Classification Level; SF-36= Medical Outcomes Study 36-Item Short-Form Health Survey; TUG= Timed-up-and-go; 6MWT= 6-minute walk test; AMWAP= Special Interest Group in Amputee Medicine Work Group Amputation and Prosthetics Mobility Score; BAP= Bone-anchored prosthesis

Osseointegration may improve function for people with poor outcomes in a traditional transfemoral socket

Ashley Carvalho, MPO carvalhoash6@gmail.com
University of Washington, Division of Prosthetics and Orthotics

References

1. Sullivan J. Chapter 50: Prosthetic Management of Osseointegration. In: *Atlas of Amputations & Limb Deficiencies, 4th Edition*. Vol 2. 4th ed. AAOS; 2018:583-595.

2. Forsberg J, Brånemark RP. Chapter 49: Osseointegration: Surgical Managment. In: *Atlas of Amputations & Limb Deficiencies, 4th Edition*. Vol 2. 4th ed. AAOS; 2018:575-582.

3. Al Muderis M, Lu W, Tetsworth K, Bosley B, Li JJ. Single-stage osseointegrated reconstruction and rehabilitation of lower limb amputees: the Osseointegration Group of Australia Accelerated Protocol-2 (OGAAP-2) for a prospective cohort study. *BMJ Open*. 2017;7(3):e013508. doi:10.1136/bmjopen-2016-013508

4. Kunutsor SK, Gillatt D, Blom AW. Systematic review of the safety and efficacy of osseointegration prosthesis after limb amputation. *BJS Br J Surg*. 2018;105(13):1731-1741. doi:10.1002/bjs.11005

5. Hagberg K, Ghassemi Jahani SA, Kulbacka-Ortiz K, Thomsen P, Malchau H, Reinholdt C. A 15-year follow-up of transfemoral amputees with bone-anchored transcutaneous prostheses. Bone Joint J. 2020;102-B(1):55-63. doi:10.1302/0301-620X.102B1.BJJ-2019-0611.R1

6. Brånemark RP, Hagberg K, Kulbacka-Ortiz K, Berlin Ö, Rydevik B. Osseointegrated Percutaneous Prosthetic System for the Treatment of Patients With Transfemoral Amputation: A Prospective Five-year Follow-up of Patient-reported Outcomes and Complications. *J Am Acad Orthop Surg*. 2019;27(16):e743-e751. doi:10.5435/JAAOS-D-17-00621

7. Leijendekkers RA, van Hinte G, Frölke JP, et al. Functional performance and safety of bone-anchored prostheses in persons with a transfemoral or transtibial amputation: a prospective one-year follow-up cohort study. *Clin Rehabil*. 2019;33(3):450-464. doi:10.1177/0269215518815215

8. Van de Meent H, Hopman MT, Frölke JP. Walking ability and quality of life in subjects with transfemoral amputation: a comparison of osseointegration with socket prostheses. *Arch Phys Med Rehabil*. 2013;94(11):2174-2178. doi:10.1016/j.apmr.2013.05.020