Comparison of the Total Surface-Bearing Socket and Patellar Tendon-Bearing Socket for Patients with Transtibial Amputation

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Clinical Question: Which socket design (total surface-bearing vs patellar tendon-bearing) provides the best clinical outcomes for individuals with transtibial amputations (TTA) who regularly wear a prosthesis?

Background: An optimal socket design provides three main functions for an individual with any lower-limb amputation: a rigid attachment for the distal components, a mechanical means to transfer energy between the patient and the prosthesis, and protection to the residual limb (RL) from damaging pressures or forces. Repetitive mechanical loads placed on the RL during ambulation via the socket can lead to many negative effects such as uneven weight distribution on the RL, pistoning, and skin irritation.[2]

Two common transtibial socket designs that help manage how the loads are transferred to the RL are the patellar-tendon bearing (PTB) socket and the total surface-bearing (TSB) socket. The PTB socket is designed to distribute loads onto the more pressure tolerant areas of the patellar tendon and the medial tibial flare, among others, and to relieve pressure from tissues over the fibular head and tibial crest.[3] The TSB socket takes the opposite approach and attempts to evenly distribute the pressures around the entire surface of the RL. This design is based on the premise that distribution of the loads over larger surface area will reduce localized pressures on the RL. TSB sockets use gel or silicone liners to maximize the load-bearing surface area over the entire RL.[1]

Search Strategy: Databases searched: PubMed, Web of Science

Search terms: (((((TSB) OR PTB) OR Hybrid) AND Transtibial) AND Socket)
Inclusion/Exclusion criteria: English, primary source in peer-reviewed journal, published 1997-present

Synthesis of Results: Four studies that used between 9 and 32 participants were identified (see Evidence Table). Outcome measures included patient satisfaction, walking speed, cost to manufacture and fit, and suspension effect. There were no differences regarding patient comfort using the satisfaction domain of the validated and established PEQ test[4], while an invalidated survey suggested greater patient satisfaction (50% satisfied and 25% somewhat satisfied) with the TSB.[6] These two studies also differed in the TSB fabrication technique and how the subjects were recruited. The study that randomized patients into PTB and TSB treatments showed no difference in the PEQ[5] while the study showing more positive results for the TSB socket used subjects who were already recommended for a TSB socket from their healthcare provider.[6] Self-selected walking speed (SSWS) is one of the six vital signs of gait.[7] One study found no difference between the TSB and PTB SSWS[5] using kinematic data analysis, while the other found an increase in SSWS using average speed over a 12 m walkway from 65.6 cm/s to 74.1 cm/s for the PTB and TSB, respectively.[8] One study looked directly at movement of the RL in these two sockets in weightbearing (WB) with x-ray and while walking using cineradiography. This was measured by the distance and angle between the tibia and the socket. It found the TSB socket provided smaller measurements than the PTB socket in each case, respectively: movement between the distal tibia and socket end at 2.53cm vs 3.60 cm when moving to WB and 0.41cm vs 0.60 cm when walking, and a tibial axis to prosthetic axis change of 4.3° vs 9.6°.[9] Evaluating cost is a complex task that involves material cost as well as patient time and visits, clinician time, and much more. Material cost was found to be greater with the TSB by about 66%, but the total time spent with the CPO was less by almost 6 hours. The total number of visits by the patient was similar at 5.42 to 4.79 days for the TSB and PTB, respectively.

Clinical Message:
The effect of using TSB socket designs on patient clinical outcomes remains unclear. Studies using validated metrics and study designs to minimize bias showed no difference[5] while studies using non-validated methods showed a preference toward the TSB socket.[6,8] Future research should focus on using standardized and valid clinical outcome measures while increasing sample size. The use of a certain socket design should continue to be based on the clinical judgement of the prosthetist collaborating with the patient and the healthcare team.

Evidence Table:

	Selles, 2005[5]	Yigiter, 2002[8]	Hachisuka, 1998[6]	Narita, 1997[9]
Population	26 adults unilateral TTA, over the age of 18, walking with prosthesis for 1 year, active walker with/ without walking aide	20 unilateral TTA patients, ages 15-37, attending the first prosthetic fitting, traumatic amputation	32 TTA patients use PTB or Kondylen-Bettung Münster (KBM) socket and prescribed the TSB.	9 TTA patients, ages 19-74, previous PTB socket users for temporary or normal walking, 6month – 2 years prior use
Study Design	Randomized control trial pre- and post-test.	Experimental comparison	Case series	Experimental Comparison
Intervention	ICX TSB Socket	PTB Socket	TSB Socket	TSB with ICEROSS
Comparison	Conventional PTB socket	TSB Socket	Previous use of TSB or KBM	Conventional PTB socket
Methodology	Control group with PTB socket compared with group in TSB socket. Baseline Patient satisfaction questionnaire (PEQ), 15m track gait analysis, economic costs, ADL analysis compared to after 3 months of use.	10-day training on PTB and TSB in balancing, weight shift, gait, and ambulatory activities; After training testing conducted	9 subjects given TSB in addition to their PTB to wear alternately and asses. Others given new TSB. All given a subjective assessment to evaluate advantages and disadvantages.	Lateral x-rays taken in WB and suspension (added 5kg mass on foot) position. Lateral cineradiography taken in walking. Measurements taken at heel strike and swing phase.
Outcomes	Patient satisfaction of function, mobility, pain, and overall mobility activities abilities Material and manufacturing costs Kinematic gait data	Weight bearing (WB) on amputate side, time for ambulatory activities, temporal-spatial aspects of gait, volume and suspension of socket	Overall 50% and 25% of patients were "Satisfied" and "Somewhat Satisfied" with the TSB.	Difference in measured distance from tibial end to socket base (WB – suspension position) Movement of stump during walking Angle between tibial shaft and axis of prosthesis
Key Findings	Small changes in PEQ from baseline to post-test (4 % to 5%). Percentage of time spent standing, walking, and walking stairs over 24-hr period higher for PTB at baseline and follow-up. Cost of materials and total number of patient visits is higher for TSB, but total time spent with CPO is lower than PTB	WB more normal with TSB 42.6% (vs 38.0%), avg. difference in intact and amputated side step length smaller (1.1 cm) for TSB than PTB (5.0 cm), shorter time for ambulation activities with TSB, better suspension with TSB, increased self-selected walking velocity in TSB	Comfort to wear, ease to swing prosthesis, piston movement during walking of TSB socket received significant overall rating of "satisfied" or "somewhat satisfied." Donning and doffing prosthesis with TSB socket received significant overall rating of "dissatisfied" or "somewhat dissatisfied."	By X-ray: translation of significantly lower for TSB than PTB (2.53cm vs 3.60 cm) By Cineradiography: Mean translation significantly less for TSB than PTB (0.41cm vs 0.60 cm) Mean angle changes significantly smaller for TSB than PTB (4.3° vs 9.57°)
Study Limitations	Lack of blinding for researchers. Multiple potentially confounding variables not accounted for (i.e., effects of gel liner within socket, comorbidities) and could not be accounted for given the small sample size.	Unclear validity and repeatability of methods for taking measurements (i.e., balance evaluation, selected step length and cadence for calculated velocity). Lack of blinding for researchers taking measurements	Method of subjective patient satisfaction assessment was not validated therefore reliability is unknown.	Lack of blinding for researchers. Multiple potentially confounding variables not accounted for (i.e., fabrication of sockets, conditions during walking) and could not be accounted for given the small sample size.

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