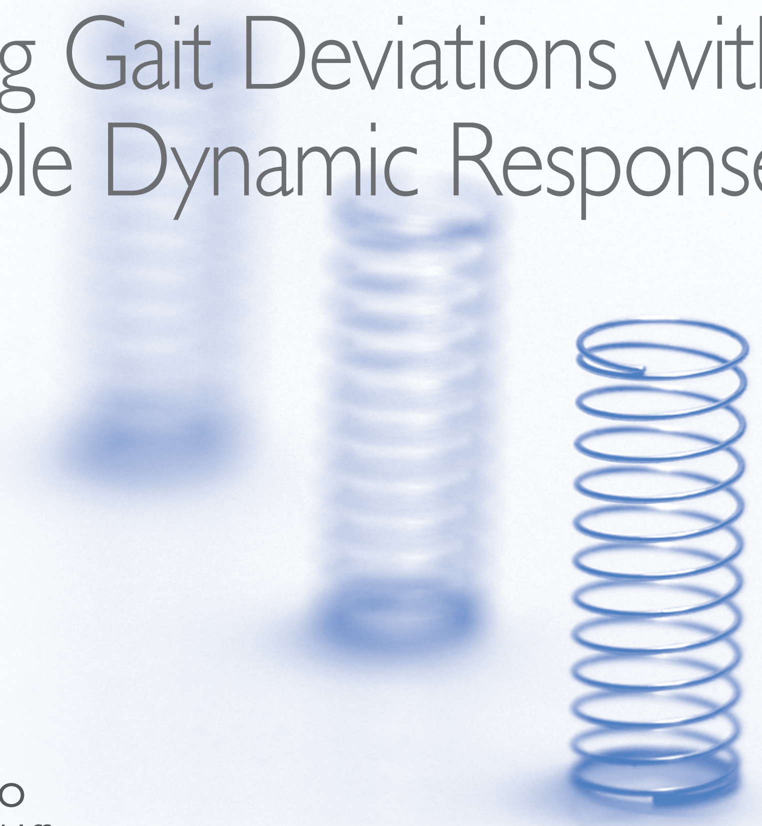
Managing Gait Deviations with Adjustable Dynamic Response



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Adjustable Dynamic Response (ADR) is a new concept for most orthotists. The ability to store and release energy that is adjustable for the individual or for changing gait patterns has not received a lot of attention.

What is Adjustable Dynamic Response? In the prosthetic field, we have been talking about the ability to offer dynamic response since the introduction of dynamic-response feet in the mid-1980s[1]. Dynamic response prosthetic feet were designed to address the limitations of SACH and single-axis feet. That is, patients found SACH and single-axis feet to be too stiff to permit comfortable ambulation at more than a moderate pace[1]. Dynamic response feet address this limitation and are now embraced by clinicians and patients as being the preferred feet for not only highly active amputees, but also those who simply desire improvement for routine daily walking. The practitioner can use what exists for dynamic response in the prosthetic field and relate it to an understanding of using adjustable dynamic response (ADR) in orthotics.

The use of ADR in orthotic management stemmed from many of the same reasons for use of prosthetic dynamic-response feet. Typically, solid ankle design AFOs and drop lock or bail style knee joints are too restrictive for patients, while free motion may not provide enough stability. Rigid stops may be too abrupt to allow a smooth rollover. Dorsi-assist joints may provide an increased toe-pickup during swing, but not facilitate smooth rollover during stance. Selecting the appropriate trim lines, and ankle and/or knee components for patients relies more on the experience of the treating clinician than on scientific rationale. Matching the involved weakness of patients with the perfect orthosis sometimes becomes a matter of trial and error, or at least adjustment and modification, for maximum improvement in the patient's gait. ADR for use in orthotic management has been developed to help address these limitations. ADR is the result of the marriage of gait analysis and the development of compensating orthotic technologies to address gait deviations seen throughout the gait cycle, particularly during stance.

Orthotic Management in the Stance Phase

The stance phase of gait entails 60 percent of the gait cycle. Because stance is where patients spend most of their time during ambulation, this area deserves considerable attention when considering orthotic management. According to J. Perry, the primary function of the muscles during stance is to stabilize the joints as the body weight progresses over the supporting limb[2]. In normal gait, internal muscles successfully restrain the torque being applied to the limb (internal or supply torque) by the external ground reaction forces (external or demand torque). In pathological gait, the supply torque fails to respond appropriately to the demand torque. Shock absorption of the limb is compromised due to inadequate muscle response. Providing a means of balancing internal torque supply with external torque demand during the stance phase of gait is the primary focus of ADR.

Marriage of Supply and Demand

ADR can be viewed as a marriage between inherently weak musculature with an external source of torque restraint. By marrying muscles that are not able to properly respond to ground reaction forces with an external component, we aim to achieve a union of balanced torque responses. This union allows patients with pathological gait the ability to have a gait pattern more similar to normal. Also, knee and ankle motion does not have to be compromised. The USS™ ankle joint from Ultraflex allows 0-40º of dorsi-flexion and plantar-flexion and the USS knee joint allows 0-30º degrees of knee flexion during stance. Ultraflex's UltraSafe-Step knee and ankle components allow ROM to occur as close to normal throughout the gait cycle, yet be dynamically constrained as needed to prevent instability.

Double-Action Ankle Joint Departure

A traditional double-action ankle joint (DAAJ) most commonly utilizes compression springs in the posterior channel to provide a dorsiflexion assist (Fig.1). Two springs used in combination with each other (medial and lateral) provide approximately 18 in/lbs of toe pick up[3]. This method is often very effective in promoting clearance of the foot during swing. However, the design is not intended to provide appropriate torque restraint for stance phase control. In addition, a rigid stop is commonly used in a DAAJ to prevent the foot from slapping during the initial part of the stance phase. This ground reaction force in turn goes from the ankle to the knee[3].


Figure 1

The Ultraflex USS ankle joint uses elastomers (Fig. 2) in the anterior and posterior channels of the component to restrain the tibialis anterior during loading response and the gastroc-soleus complex during terminal stance. The torque response for these elastomers provides 0-240 in/lbs for the tibialis anterior and 0-360 in/lbs for the gastroc-soleus complex. The elastomers allow for shock absorption, preventing ground reaction forces from adversely effecting more proximal joints.

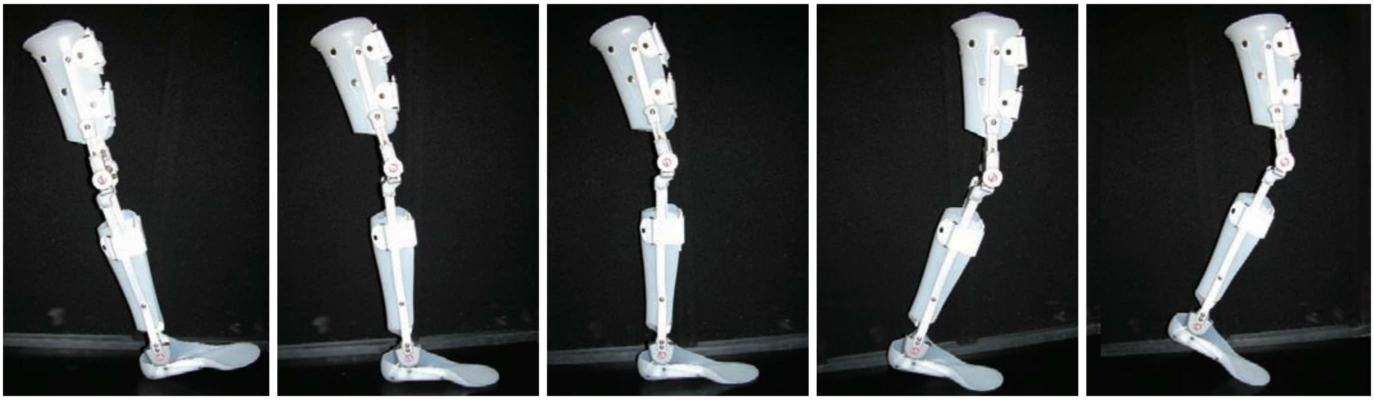

Figure 2

Ultraflex Knee Joint Difference

For the most part, Stance Control Orthoses (SCOs) lock the knee joint to provide knee stability during stance and unlock during swing to promote more natural ROM, flexion of the hip and foot clearance. SCOs are designed primarily for patients with isolated quad weakness, so patients with more involved lower extremity weakness are often excluded from being candidates for such orthoses. In contrast, the Ultraflex USS knee joint is designed specifically for use on patients with more involved lower extremity weakness, which is far more common in clinical practice.

Looking at the data for sagittal plane ROM at the knee during stance, in normal gait the knee typically goes from 3º to 18º during loading response and near 40º by pre-swing (Fig.3).

The ADR knee joint allows from 0-30º ROM available for both the stance and the swing phases of gait. Elastomer bumpers work to augment the quadriceps function and dampen the ROM. If a patient needs maximum stability in the initial part of



Ultraflex ADR CAFO demonstrating the five phases of stance: Initial Contact, Loading Response, Mid-Stance, Terminal Stance and Pre-Swing.

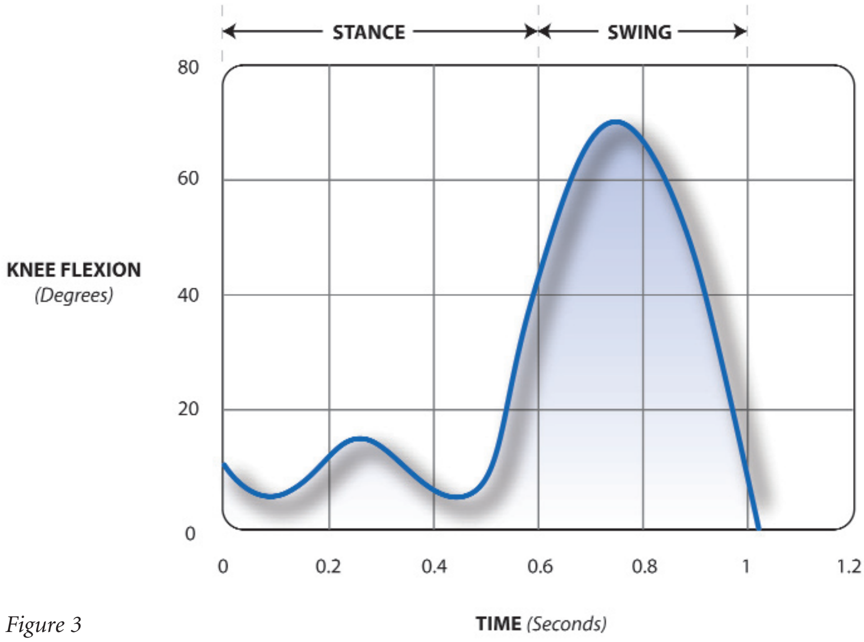
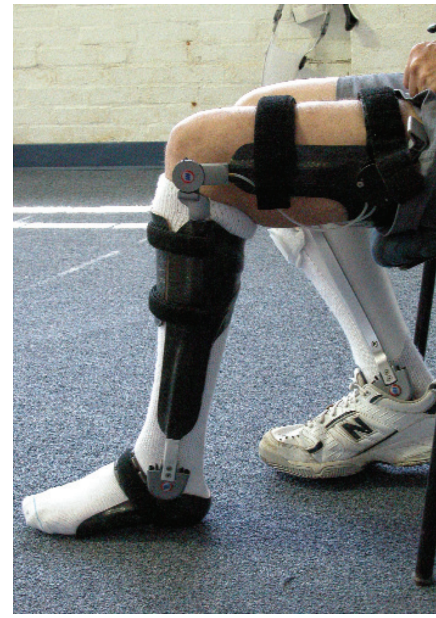


Figure 3



their rehab process, the joint can be locked in full extension. As they gain strength throughout their rehab process, the joint can be adjusted to allow more ROM to mimic more normal gait.

ADR Performance Powered By Carbon Fiber

ADR and carbon fiber technologies can offer a very successful combination for the right patients. Carbon fiber offers increased strength, decreased weight, increased intimacy of fit, and better translation of forces to orthotic componentry than standard plastics.

In a recent case study, a patient was converted from a traditional plastic KAFO with limited motion to a USS KAFO with ADR with promising results. The USS KAFO demonstrated how ADR technology provides stance support at both the knee and the ankle dynamically. This minimizes compensations, while allowing more normal knee-ankle-foot biomechanics (knee flexion and ankle-foot roll-over) to maximize speed at reduced energy cost.

Who Can Benefit from ADR?

ADR was originally developed for the changing needs common to stroke survivors. As patients progress with their rehabilitation program, it's common to see varying amounts of strength, balance and coordination return to the patient. The technology allows for increased stability in the early phases of rehabilitation and less restriction of available muscle use in the latter phases. ADR not only suits the needs of stroke survivors, but almost any patient affected with gait inefficiencies such as quadriceps weakness, paralytic equinus or crouch gait can benefit.

Focusing on Ability, not the Disability

ADR represents an exciting area of technological advancement in the field of orthotics. By understanding how normal gait occurs and how we want to fully address the gait cycle in individuals with pathological gait, we can implement a more thorough approach to gait management. Ultraflex's USS knee and ankle components offer patients dynamic stability and safety without limiting ROM or use of inherent muscle strength. As orthotic clinicians, it's a privilege to offer a technologically advanced solution that focuses more on the ability of the patient than the disability.

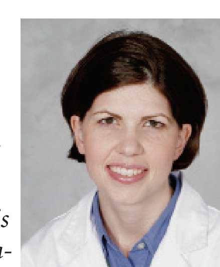
For more information on Ultraflex USS™ Technology, contact Ultraflex's Clinical and Technical Support at 1-800-220-6670.

References:

[1]Michael JW. *Prosthetic Suspensions and Components.* Atlas of Amputations and Limb Deficiencies. Third Edition. 2004; 33:409-427.

[2]Perry J. *Ground Reaction Force and Vector Analysis.* Gait Analysis Normal and Pathological Function. 1992; 19:413-429.

[3]Lunsford T. *Orthology: Pathomechanics of Lower-Limb Orthotic Design.* 1998; 20-34.



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