A CLOSER LOOK AT COMPONENTRY
In part two of the componentry series, prosthetist Geoff Hill explains knees.

There are a huge number of prosthetic knees available, making it hard to choose the right one. It would not be practical to discuss the merits of individual models of knee because of this wide range. Instead this article will outline, in very broad terms, the main categories available.

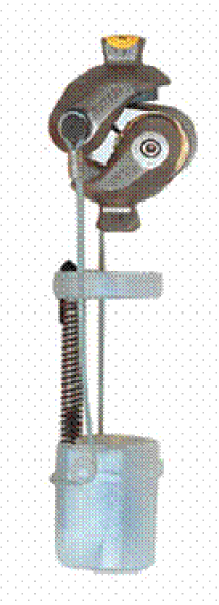
What does a knee have to do?

- Support the body, bearing in mind that the weight, the support surface (ground) and speed and direction of movement will all vary.
- Swing the foot forward smoothly at speeds from a slow stroll to running
- Allow the body to move forward over the leg smoothly. This is done by adjusting the amount of bend in the knee to smooth out the rise and fall of the body.
- Bend to allow sitting, squatting etc.

Can prosthetic knees do this? Well all can do some of it, some can do most of it, but none can do all of it. And the more they try to do, the more weight and cost is incurred.

The simplest knee is the locked knee. These allow no bending of the knee when walking, which very effectively meets the support requirement. However the result is a very awkward, but very safe, stiff legged gait. The lock can be released for sitting. Because of the awkwardness these are usually only used for frail users or sometimes for training purposes.

One of the most commonly used knees is the weight activated brake or **'safety' knee**. This has a mechanism that locks the knee when weight is applied but frees it up to allow it to swing forward when the weight is taken off.
This makes walking fairly safe. However they can fail to lock under certain circumstances, eg uneven ground, where the weight may be too far behind the knee.



Generally speaking these knees can be set up with different amounts of 'safety'. This means that when the knee is set up to lock easily it can take more effort to 'break', but if it is set up to break easily it can feel unsafe when walking. Quite what the best setting is depends on the individual, so make sure and work with your prosthetist to find a setting that you are comfortable with. Some people do find it hard to find a setting that allows them to feel they are walking both smoothly and safely.

Another problem with these knees is that most have only one setting to control how quickly the knee swings forward. This can make it hard to vary your walking speed as you may have to wait for the knee to catch up when walking quickly, or if it set to swing quickly it may 'knock' at the end of it's swing.

Some knees have a pneumatic mechanism that can vary the speed the knee swings at. While they have their limitations they can make the knee feel that it swings in a smoother and more natural manner. Naturally they add weight and cost to the knee.

Probably the next most commonly used knees are **polycentric**, often called ‘4 bar’ knees. These do not have a locking mechanism as such. Instead they rely on an arrangement of linkages which moves the axis, or pivot point, of the knee further behind the body of the wearer. This means that the wearers weight tends to push the knee straight when standing, but allows it to bend when walking.

These often feel smoother to walk with. This is because there is no brake to unload and because the linkages mean that the knee rotates about a moving axis, not a single point, which more closely mimics an anatomical knee.

The disadvantage is that there is no ‘back up’ in the knee, so if the wearer loses control or mis-steps they are more likely to fall. For this reason they are considered less safe and are often fitted for stronger or more agile users.

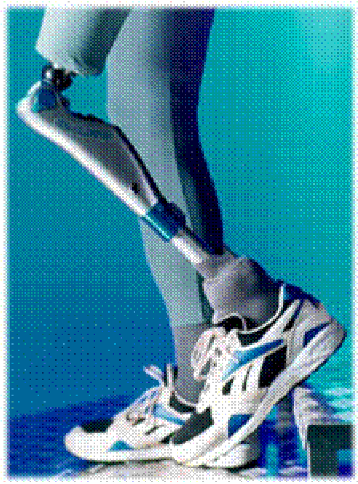
Like safety knees they often only have one setting to control their swing, but can also be found with pneumatic swing control with the same advantages and disadvantages.

Hydraulic knees, come in a number of configurations, but basically rely on a hydraulic cylinder to both support the knee from bending too quickly when the weight is on and control the speed at which it swings. This has a number of advantages – the wearer can tackle different terrains or tasks knowing that the knee cannot collapse completely. The hydraulics also alter the speed that the leg swings at so allowing the user to walk faster without having to wait for the knee to straighten. However hydraulic knees can require some effort to ‘break’ at slow speeds, though momentum largely does the job at faster speeds. They also add significant weight and cost. For these reasons they work best on more robust, active users. Slower users find that they carry extra weight but get little benefit compared to simpler knees. These users often end up with a stiff legged gait, as they fail to ‘break’ the hydraulic mechanism.

All of these knees meet the conditions of providing support and of swinging forward, but are effectively stiff when the weight is on them. This ignores the third requirement, which is to smooth out the body’s progression.

A number of knees try to meet this condition. They use various mechanisms to allow ‘stance flexion’ – this means that they bend a little as the body weight comes onto them. This smoothes out the movement of the body as it passes over the prosthesis as well as absorbing some of the impact of landing on a rigid limb. However many people find the initial bend disconcerting, especially if they have become used to rigid knee units.

The latest addition to the catalogue is **microprocessor-controlled knees**. These have an on board chip and sensors which ‘read’ the users gait and modifies the knee settings accordingly. This allows smoother walking at a very wide range of speeds. It also helps with going down slopes and stairs with most users managing a ‘step over step’ descent. These knees can also give some degree of stumble recovery, whereby the knee senses a stumble and immediately stiffens to prevent the prosthesis collapsing. This ability is not infallible and falls can still occur.



The disadvantage of these knees lies mainly in their cost, which is significant. However they are also not recommended for some environments which may damage the electronics and do have to be returned to the supplier for maintenance periodically. They must also be recharged more or less daily.

All current knees are passive, which is to say they don’t offer any propulsion. This means that above knee amputees always have less efficient walking than able-bodied people. No matter how fit they are or how good their prosthesis is. The latest development actually puts external power into the users step, so returning some of the propulsion lost with the amputation. These knees are apparently being tested but are not yet in production. How successful these will turn out to be is yet to be seen, but the potential to keep improving function for amputees is certainly there.

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