BRAKES 101

What you need to know about the gear that brings you to a halt

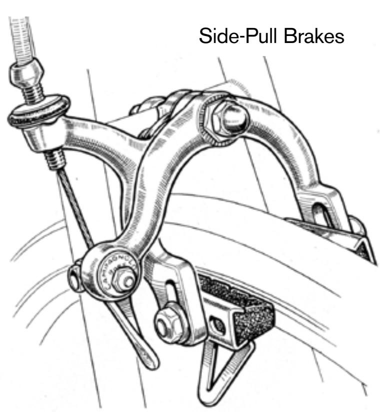
by Jan Heine

In the last "Mechanical Advantage" column, I discussed how to use your brakes most effectively. But what about the brakes themselves? There are many different types of brakes which work for different applications. First, let's cover some basic terminology and concepts. Brake power is simply how hard the brake clamps the rim. The main factor that influences brake power is the mechanical advantage of the brakes.

Mechanical advantage is easy to understand when you think of a pair of pliers: The longer the upper arms (plier grips) are in relation to the lower arms, the harder the brake clamps the rim. Brake levers also can have varying degrees of mechanical advantage, depending on where their pivot is located.

Almost as important as brake power is modulation — how finely you can control the brake power. Ideally, brake power increases linearly as you pull the brake lever, rather than the brake grabbing the rim suddenly as the pads squeeze the rim.

Side-Pull Brakes



Braking means converting kinetic energy into heat through friction. Your brake pads rub on the rim, creating the friction that slows you down. The ideal brake pads generate a lot of friction while abrading the rim as little as possible. In fact good brake pads are the first (and easiest) step toward improving your brakes.

Side-Pull Brakes

A standard side-pull brake works like a set of pliers. Increasing the length of the upper arms increases your mechanical advantage. The downside of higher mechanical advantage is that your brake pads move less as you squeeze the lever. You can pull the brake lever only so far until it bottoms out against the handlebars, so you must adjust your pads closer to the rim if your brakes have higher mechanical advantage.

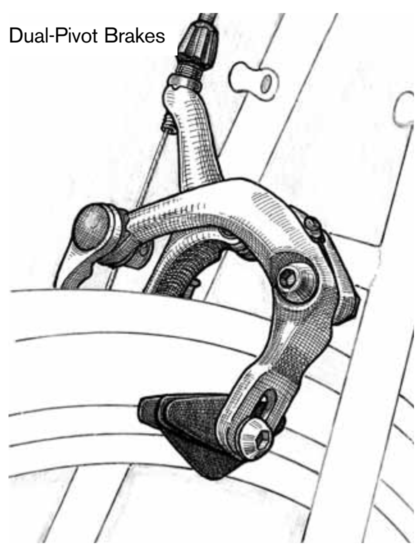
Dual-Pivot Brakes

Modern dual-pivot brakes link the two arms, so that the pads return to their original position after every brake application. (Traditional side-pull brakes tended to "wander" and not return to the same spot.) On dual-pivot brakes, you can set the pads closer to the rim without risking that they rub. This means dual-pivot brakes can have a higher mechanical advantage and thus more brake power, but if your wheel goes out of true, it will rub sooner than on a side-pull brake.

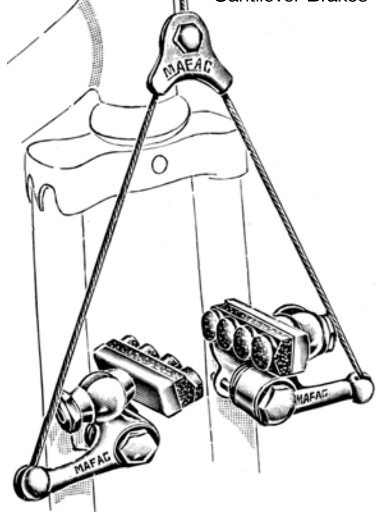
Brake Flex

When the components of your brake flex, they store energy like springs, rather than transmitting that energy to the rim. This reduces the power of your brake. Flex also can cause poor modulation if it changes the angle of the brake pads as they hit the rim. A flexible brake will feel fine when you first apply it, but as you brake harder, the brake flexes instead of squeezing the rim. No matter how hard you pull on the lever, brake power no longer increases significantly.

Dual-Pivot Brakes



Brake levers, cables, and housing flex very little, but the lower arms of the brake calipers can flex a lot. On side-pull and dual-pivot brakes, the lower arms reach all the way from the fork crown to the rim, arching around the tire as they go. With large tires, you need longer brake arms, and you get more flex. That is why dual-pivot brakes work great on racing bikes with narrow tires but not so


Cantilever Brakes

well on touring bikes with wide tires and fenders.

Brake flex usually becomes apparent only when braking very hard on a steep downhill. This means that many cyclists don't notice it — until they have to brake hard in an emergency.

Cantilever Brakes

If you move the pivots from the fork crown to the fork blades, you can shorten the lower arms and reduce flex. The length of the arms now is independent of tire size. That is the idea behind cantilever brakes. However, cantilever brakes are not perfect. The arms stick out and can get in the way of panniers or even touch your heels if you ride a very small frame. Low-profile cantilevers and V-brakes address this concern with varying degrees of success, but neither design addresses the second issue encountered by cantilevers: The brake itself may not flex much, but the fork blades and seatstays tend to twist outward when the brake is applied hard. This changes the angle at which the pad hits the rim, which can cause squealing and, worse, poor modulation when the brake suddenly locks onto the rim as you increase the brake power. Angling the front of the brake pads toward the rim ("toe-in") can counter the twisting of the fork blades.

Center-Pull Brakes

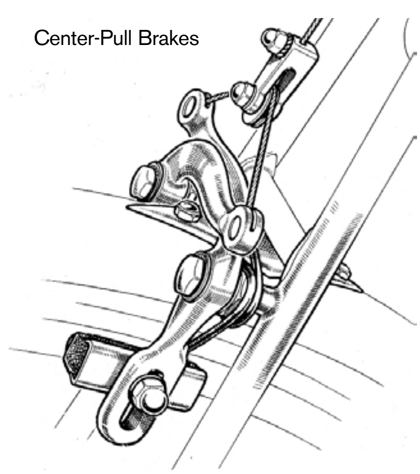
Center-pull brakes are a refinement of cantilevers which keep the short lower arms. By moving the pivot above the rim instead of below, they take advantage of the fork crown (front) and seatstay bridge (rear) to counter the twisting of the pivots. Ideally, the pivots are brazed to the frame (above), but most center-pull brakes used pivots on beefy bolt-on arches that worked just fine.

Center-pull brakes got a bad reputation when they were equipped on inexpensive 10-speeds during the 1970s bike boom, but the poor braking was mostly due to low-quality cables, housing, and brake pads, often coupled with steel rims that are too smooth to provide much friction. With good components, center-pull brakes offer excellent stopping power and modulation. Roller-cam and U-brakes were variations of center-pull brakes that were popular on mountain bikes for a time.

Disc Brakes

In effect all rim brakes are disc brakes: The bicycle rim does double duty as the brake disc. Disc brakes simply use separate brake discs. Some of the first disc brakes even looked like standard bicycle rim brakes. A separate disc has the advantage that the brake no longer needs to reach around the tire. This reduces the potential for flex in the caliper.

A separate disc is usually much smaller than the bicycle's rim and has a shorter lever on the bike's wheel. To clamp the


Center-Pull Brakes

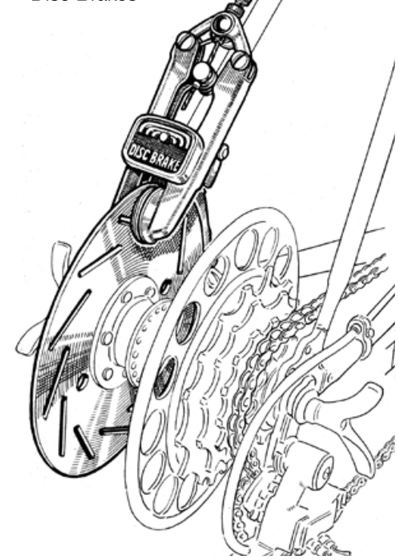
disc with enough force, the brake must have a very high mechanical advantage. This has three interesting consequences:

a) The pads must be set very close to the disc, and even a slightly warped disc will cause rubbing.

b) Water is scraped off the disc much more effectively, so disc brakes work better in the rain.

c) Flex is a bigger concern (more clamping force = more flex).

Cable-operated disc brakes suffer


Disc Brakes

especially from flex. It is difficult to set up their pads so they do not drag on the rim and still get full brake power. Hydraulic fluid transmits forces without significant losses, so hydraulic disc brakes are more powerful.

Conclusion

Brakes are important components of bicycles. Side-pull and dual-pivot brakes work best with narrow tires and no fenders because keeping their lower arms short reduces their flex. Cantilever brakes work well with larger tires and are an excellent choice for touring bikes. Center-pull brakes improve modulation by reducing the twisting of the fork blades, but there aren't many companies who offer them today. Disc brakes work well with hydraulic actuation. AC

Jan Heine is the editor of Bicycle Quarterly*, which covered the history and technology of bicycle brakes in a special issue (Vol. 7, No. 2). His blog "Off the Beaten Path" is at janheine.wordpress.com.*