EQUAL

Mechanical disc brake

Concept and Data

August 16, 2021
edition

GROWTAC

EQUAL Brand Theme

EQUAL is a brand of cycle parts for sports bikes.

The theme is "Let's build your own free bicycle".

Cycling is a sport with a large experiential and subjective aspect.
When you are on your bike, you are the star.
While climbing a long hill, you shout in your heart, “It’s hard!” When you feel a nice breeze, it makes you feel happy.
Whether you ride fast or slow, steer to the right or to the left, you are the hero.
It’s also great to feel that with your friends.
In addition to MTB and road bike, there are many other ways to have fun, such as cyclocross, brevet, gravel, and cycle camp.

How do you enjoy your bicycle?
Is it a bicycle that you, the lead, feel is the best?

EQUAL makes cycle parts that make diverse ways of having fun more enjoyable.
Make the best bike you can enjoy.
Choose the form, the color, the function, and the performance based on your own sense of value.

EQUAL does not like walls of standards or business confines.

EQUAL increases and respects the freedom to choose.

EQUAL does not hide the disadvantages as well as the advantages.

EQUAL is all about fun.

Build your own bicycle.

EQUAL

Message from the chief engineer

The trend from rim brakes to disc brakes is becoming full-scale under the leadership of major manufacturers.
It does not matter whether the user wants it or not. No one can stop it.
From now on, frames, wheels, components, and all other parts will be changed to disc brakes.
(If you like the rim brake bike you are riding now, We hope you will keep riding it.)

In this trend, the image of "disc brakes = hydraulic disc brakes" has become common. There are two main types of disc brake systems for bicycles: hydraulic and mechanical.
And the component manufacturers are all focusing on hydraulic systems, with new ones being constantly released.

What about mechanical systems?
Currently, the technology has not changed much in more than 10 years and is recognized as ineffective and of low grade.
However, the mechanical system has many advantages when considered in bicycle applications.
So we had a question.
Is the hydraulic system the right answer for all users in all genres, road, MTB, cyclocross, gravel, etc.?
If there were mechanical disc brakes that worked well, wouldn't there be more brakes to choose from based on purpose and preference?

We have seriously confronted the problems of current mechanical disc brakes and overcome the weaknesses of the mechanical type.
What we want to create is not just a "good mechanical disc brake".
We want to give you the freedom to choose the brake system that best suits your style and enjoyment.
We hope you will enjoy your bike as much as you can.

Masayuki Kimura, GROWTAC Inc.

Introduction

In this document, the words "bicycle" and "sports bicycle" appear. The definitions are: Bicycles that are not exposed to rain, are stored indoors, are for sports, and are regularly maintained. Disc brakes are used on many bicycles (mamachari* style ~ 1 million yen or more).

*City bicycles are unique to Japan.

For example, the requirements for bicycles that are exposed to rain and competition bicycles are completely different.

This definition is important to avoid misunderstandings.

Calipers of the hybrid type (hydraulic and mechanical) are not included because it is not possible to make a definite evaluation due to the presence or absence of a master cylinder and the many variations in quality.

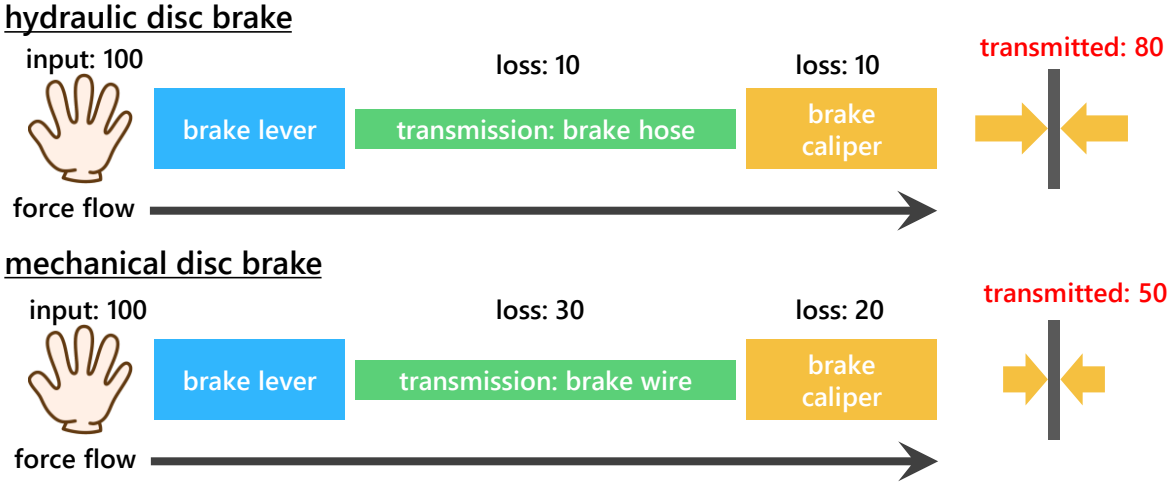
Disadvantages of mechanical disc brakes for bicycles

✓ Does not work
✓ Heavy
✓ Low grade image

Maybe you have an image like this.
In fact, it is probably the same.
So why do mechanical disc brakes for bicycles have these disadvantages?

✓ Does not work

In the first place, the source of the force that the brake pad pinches the rotor is the "hand force" that pulls the lever.
The hydraulic system and the mechanical system are the same.
However, the braking force is higher for the hydraulic type.
There are three main parts that make up a disc brake: the brake lever, the transmission, and the brake caliper.
The mechanical type has a large loss at each part, and the force to pinch the rotor at the end is weak, so the brake does not work. In addition, the wire system of the transmission part is not rigid, so the touch becomes fluffy.



Note: Numerical values are used for easy understanding.

✓ Heavy

Mechanical system requires a mechanical boosting mechanism with screws or levers inside the caliper.
On the other hand, the hydraulic system is piston only.
The power is increased by Pascal's principle.
Mechanical system is more complex in structure and have more parts.
Due to cost limitations, lightweight materials cannot be used for parts.
In the first place, no one buys brakes that do not work, even if they are lightened at a cost.

✓ Low grade image

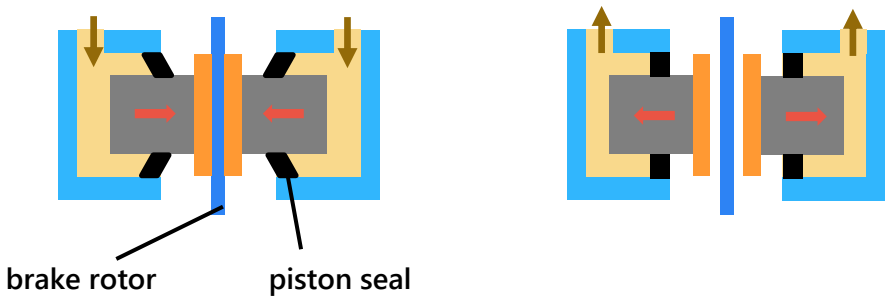
“doesn't work" and "heavy" brake calipers will not be installed on high-grade bicycles. In other words, it will be a relatively inexpensive bicycle.
Then, "cheaper is better", and the mechanical type becomes heavier and less effective braking system.
It seems that a low-grade image was created by increasing the number of such items.
There are some good ones these days, so this isn't the case, but it doesn't change the image.
It's a shame because there are some advantages unique to the mechanical type.

Features of operation from structure

Now let's check the difference between hydraulic and mechanical disc brakes other than the effectiveness and weight.
The purpose of pinching the rotor with the pads is the same, but the operation to achieve it is completely different.
This characteristic of operation is a very important factor in disc brakes for bicycles.

Hydraulic type

Opposed push pistons is mainstream.
In principle, even if the brake pads are worn, the reduced amount will come out automatically.
Automatic adjustment of clearance between rotor and pad.
Pad clearance depends on the deformation of the seal and is not certain.

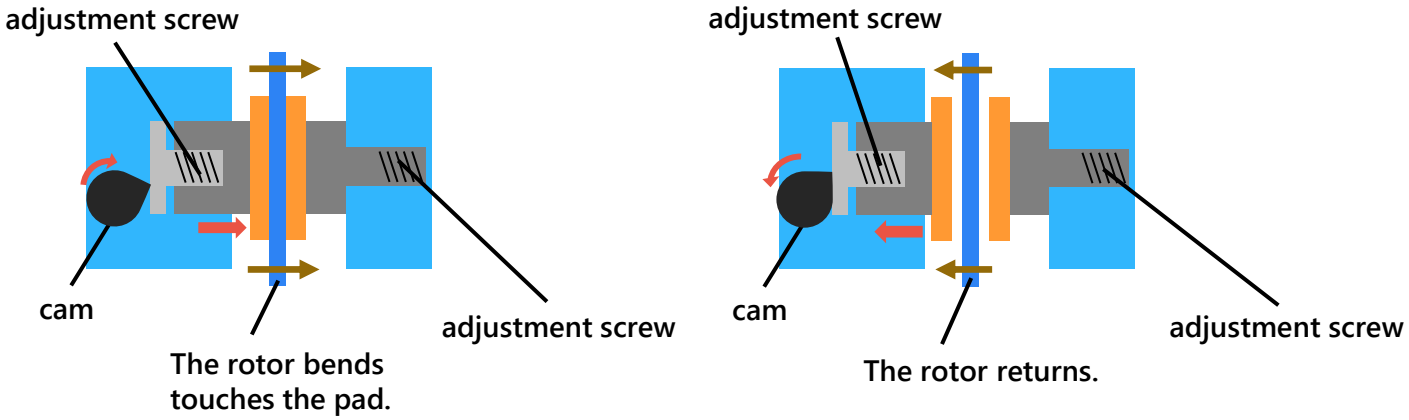


Closing operation:
When hydraulic pressure is applied to the caliper, the piston and pad are pushed to apply the brake.
At this time, the piston seal is deformed.
With respect to pad wear, the piston comes out more than the amount of deformation of the piston seal, so the piston is pushed out by the amount of wear.

Opening operation:
When hydraulic pressure is released, the deformed piston seal returns to its original position, and the piston and pad return. The clearance between the rotor and pad is the amount of this return.

Mechanical type

Single-sided push piston is the mainstream.
The pad clearance is not automatically adjusted, but the piston and pad will definitely return to their home position.
The pad clearance can be adjusted with the adjustment screw.



Note: The figure shows the structure of EQUAL, and there are also screw type etc.

Closing operation:
The brake wire turns the cam and pushes the piston and pad to apply the brakes.
At this time, the rotor is also pushed and deformed, and hits the pad on the opposite side.
(There is a theory that the mechanical type does not work due to the deformation of the rotor, but it has little to do with it.)

Opening operation:
When the brake wire loosens, the cam turns in the opposite direction, and each pad and rotor surely return to their home positions.

About mechanical "double-sided push" and "single-sided push" pistons

It works because it is "double-sided push", and it does not work because it is "single-sided push". We often hear such stories about disc brake calipers.
We think this is largely influenced by hydraulic type and the image of motorsports.
So what is the difference between double-sided push and single-sided push when actually considering the unique structure of a bicycle?
And which is better for the mechanical type?
To conclude, "single-sided push" might be possible to say that suitable for mechanical disc brakes for bicycles.

About hydraulic “double-sided push” and “single-sided push” (surface area of piston)

According to Pascal's principle, if the surface area of the master cylinder is the same, a larger force will be generated if the piston area on the caliper side is larger.
In other words, the area of the opposed (double-sided push) pistons is twice as large as that of the single-sided push, and the force to pinch the rotor is larger. Even with single-sided push, if the area is large, a large force will be produced.
Actually, it is better to use opposed pistons because it is convenient to place the piston on the outside of the rotor as much as possible.
However, it is not as simple as just making the pistons bigger, as there is a conflict with the stroke of master cylinder, and the entire brake system needs to be designed.
This means that opposed (double-sided) push pistons are better than single-sided push pistons in the case of hydraulic type with the same piston surface area.

About hydraulic double-sided push and single-sided push (caliper structure)

Taking a car as an example, the brake rotor is stiff and does not bend laterally.
In hydraulic type with opposed (double-sided push), in this case, pad clearance is maintained on both sides of the rotor.
However, in the case of single-sided push, it is not possible to pinch the rotor or make pad clearance.
This is where the "floating caliper" structure comes in.
(There is a lot of information on the internet about floating calipers, so please check it out.)

If it is a floating caliper and opposed (double-sided push) type, the opposed (double push) type will have higher performance in terms of lightness, rigidity, response, etc.

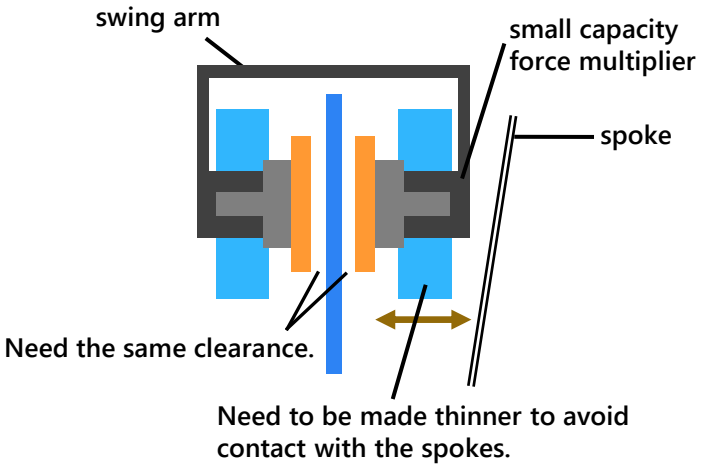
From two things, in the case of "hydraulic type", there is an image that "double-sided push is high performance".
The problem is to apply this image to all vehicles and all disc brakes.

About "double-sided push" and "single-sided push" of bicycle

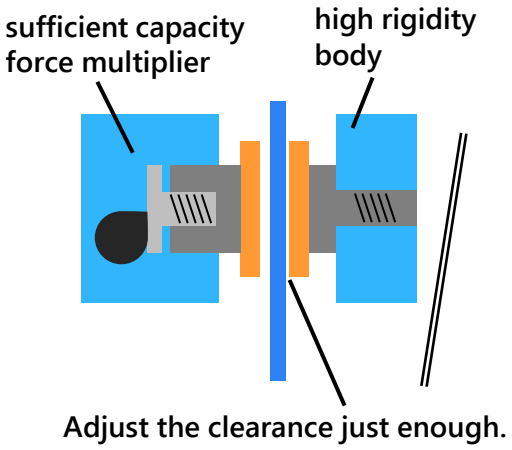
We think that the hydraulic type of bicycle is also good as the above image.
However, it is not the same for the mechanical type.
The assumption is that the rotor will bend in a lateral direction.
In other words, there is no need to make it a floating type.
At this point, it is not possible to discuss the superiority of floating calipers and opposed (double-sided push) calipers.

(There is a theory that the bending force of the rotor is the cause of the ineffectiveness of mechanical type. However, the bending force is small and almost irrelevant.)

The force boosting method is not Pascal's principle, but by the mechanism of the lever and screw.
That is, the piston area does not matter.
So where is the superiority of mechanical double-sided push and single-sided push?
It is a boosting mechanism.
In the case of mechanical double-sided push, a boosting mechanism is required on each of the left and right sides.
The number of parts is also doubled. The operating resistance in the mechanism also increases.
And the inner (spoke side) mechanism must be inserted between the rotor and the spokes.
The actual width allowed for the mechanical part is about 10 mm.
If a mechanism that generates a force that pushes a pad of up to several hundred kilograms is inserted in this gap, the parts will become smaller, and there is a high possibility that the rigidity will be insufficient, and the life will be shortened.
Also, if the pad clearances on both sides are not adjusted to the same level, the phenomenon will be close to one-sided push.
In EQUAL, we chose "single-sided push", which has a small number of parts, high rigidity, and long life, instead of the unreasonable double-sided push.
<u>It does not mean which is the correct answer, but which one is "suitable".</u>



<u>Mechanical double-sided push type</u>



<u>Mechanical single-sided push type</u>

Note: The figure shows the structure of EQUAL, and there are also screw type etc.

The mechanical double-sided push type also has advantages.
If the pad clearances on both sides are the same, the feeling of the pads hitting the rotor will be direct and clear.
For the single-sided push type, adjusting the inner pad clearance to the minimum will significantly improve the feeling of the pad hitting the rotor.

Bicycle-specific manners and features

There are bicycle-only manners and features that cars and motorcycles do not have.

- ✓ **Replace wheel**
  There are multiple sets of wheelsets with rotors for one bike for practice, racing, etc.
- ✓ **Remove the wheel and carry out *rinko** or load into a car.**
  *To remove the wheels of the bicycle and put them in a dedicated bag to be carried by train.
- ✓ **Turn the bike upside down**
  Maintenance, *rinko*, loading into a car, etc.
- ✓ **Maintenance is often carried out by the user itself.**
- ✓ **Brake rotor is thin and has no lateral rigidity (bends laterally)**

Hydraulic vs. mechanical

We explained "structure" and "bicycle-specific manners" as elements other than effectiveness.
Based on this, let's compare the hydraulic type and the mechanical type by scene.

Scene	hydraulic type	mechanical type
stop	○ It works well and stops well. The front and rear braking force is about the same.	× Less effective Compared to the front, the rear brake is less effective because the wire line is longer.
when riding	△ If the movement of the piston is not good, the pad may hit the rotor and make a sound. Depending on the case, it may or may not hit.	○ A simple adjustment of the position of the left and right pads can be made by using the bolts.
wheel replacement	△ Most of the wheels have different rotor positions by a few tenths of millimeters. If the rotor touches the pad, it is necessary to loosen the caliper fixing bolt and adjust the center.	○ Simple adjustments can be made by using the bolts to adjust the position of the left and right pads.
rinko, loading into a car	△ If you remove the wheel and hold the lever without the rotor inside the caliper, the piston will come out large. A spatula-shaped tool is required to return the piston. Forcing it back in with a screwdriver or the like can damage the pads or worse, crack the piston. When removing the wheel, pad spacers are essential.	○ There is no problem even if you hold the lever without the rotor.
turn the bike upside down, lie down	△ If the air is completely bled out, including the reserve tank, there is no problem, but if the air is not bled out, air will enter the brake lines when the bicycle is turned upside down. If air gets inside at an event, you will need special tools, which is quite a problem.	○ There is no problem even if you turn it upside down or lie down.
everyday maintenance	○ No adjustment is needed for pad wear. If there is no trouble, the maintenance frequency is low and stable. Please note that the pad may be missing without you noticing it.	× The pad clearance needs to be adjusted as the pads are reduced. Maintenance frequency is high. It is also an opportunity to check the pad wear.
maintenance that requires parts replacement (DIY)	△ There are less troubles if you change the oil and seal regularly. You need to have all the necessary tools. Without proper technology, air bubble entrainment will occur. It's not difficult if you get the hang of it, but it's safer to leave it to the pro shop.	○ Basically, maintenance is similar to that of a rim brake. It is easy to understand, and wire replacement is not difficult.

Hydraulic system can be troublesome to deal with.
There are many things that can be prevented by regular maintenance and a reliable pro shop.
The mechanical system are more resistant to troubles and are less likely to cause problems during the ride.
The most important thing for a braking system is to stop.
Even if the mechanical system has many advantages, the hydraulic system is the better brake.

EQUAL mechanical disc brake

EQUAL mechanical disc brakes are the next generation of mechanical disc brakes, overcoming the disadvantages of existing mechanical systems and adding functions that have never been seen before.

There are many advantages of mechanical systems. If anything, it can be said that mechanical systems are good for bicycles. The biggest disadvantage of the mechanical system is that it does not work.
EQUAL has cleared the biggest disadvantages of mechanical braking system such as “effectiveness” and “weight”. it will become an option for many users as a braking system for bicycles.

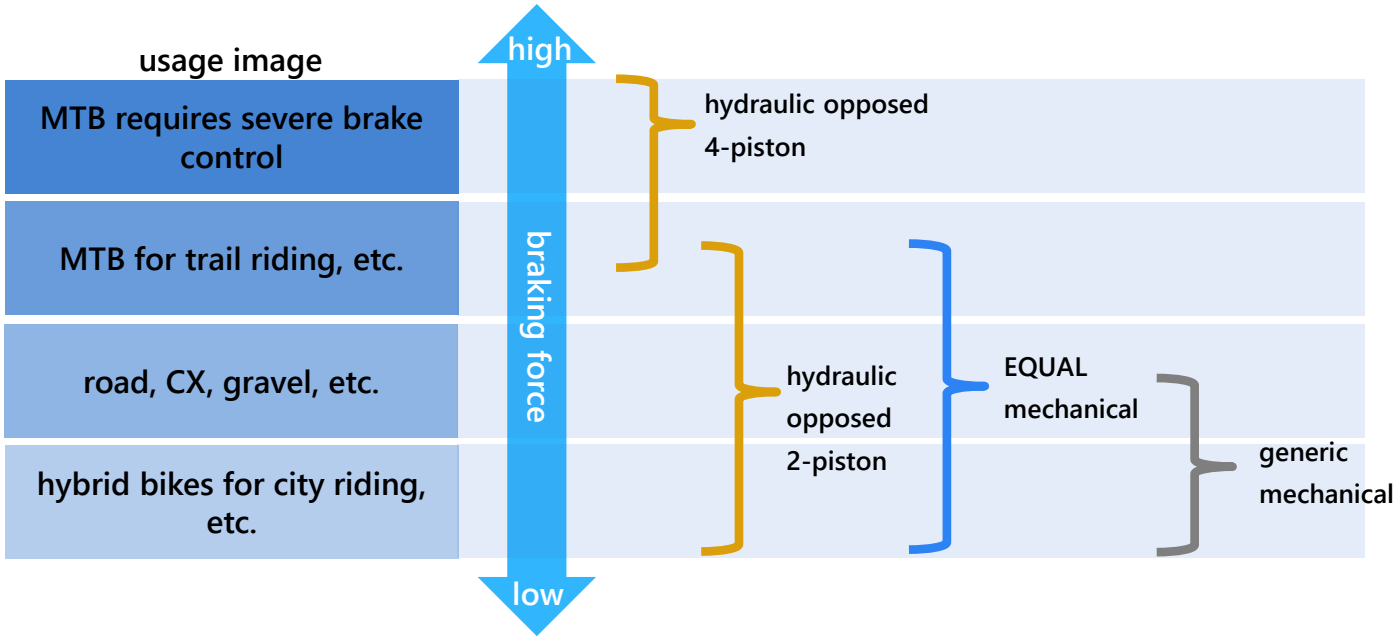
Features of EQUAL mechanical disc brakes

- ✓ High braking force
- ✓ Unique vertical cam structure
- ✓ Optimization of cable routing
- ✓ Brake-leverage adjustment function
- ✓ World's lightest class mechanical disc brake
- ✓ High efficiency cable set
- ✓ Dedicated brake pads (Shimano road compatible) engineered by Vesrah
- ✓ Other features

Although it is an EQUAL mechanical disc brake with excellent performance and functions, there are some points to be aware of when using it. In order to deepen the understanding of the product, the points to note are described in.

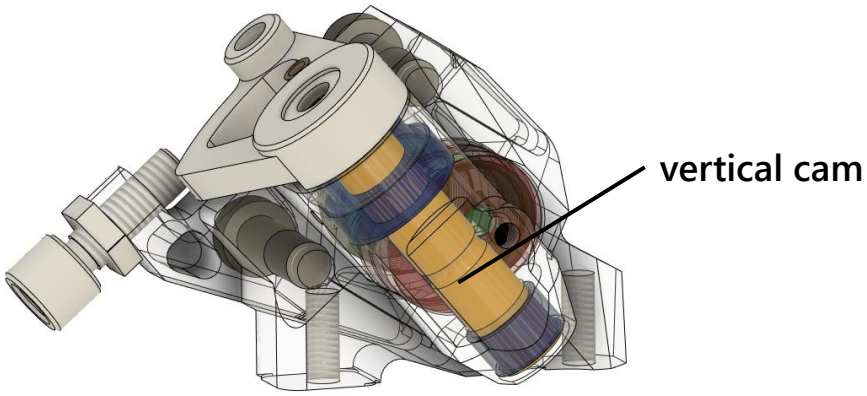
✓High braking force

As a result of the technology described below, braking force equivalent to that of a hydraulic opposed two-piston braking system has been achieved.



✓Unique vertical cam structure

Inside the mechanical caliper, a mechanism that increases the force from the cable and converts it into the force that pushes the pad is required.
Most of the other companies are horizontal screw type with the axis parallel to the ground.
EQUAL mechanical disc brake uses a unique vertical cam system.
This mechanism produces many advantages such as optimization of wire routing and realization of brake-leverage adjustment function.



✓Optimization of cable routing

Many frames now have an interior cable system.
The cable outlet of the frame is inside the fork and inside the chain stay.
With the horizontal axis screw type of other companies, the position of the outer casing holder is structurally located on the outside of the bike, so it is necessary to sharply bend the cable route from the inside to the outside. The swaying resistance of the wire also increases, which adversely affects the effectiveness. The installation itself can be difficult.
In the vertical cam type EQUAL, the outer holder is inside the bicycle, and the cable connects straight from the exit to the caliper. It will improve the assembly, effectiveness and appearance.

generic horizontal axis type

EQUAL

comparison of front brakes

generic horizontal axis type

EQUAL

comparison of rear brakes

✓Brake-leverage adjustment function (patented)

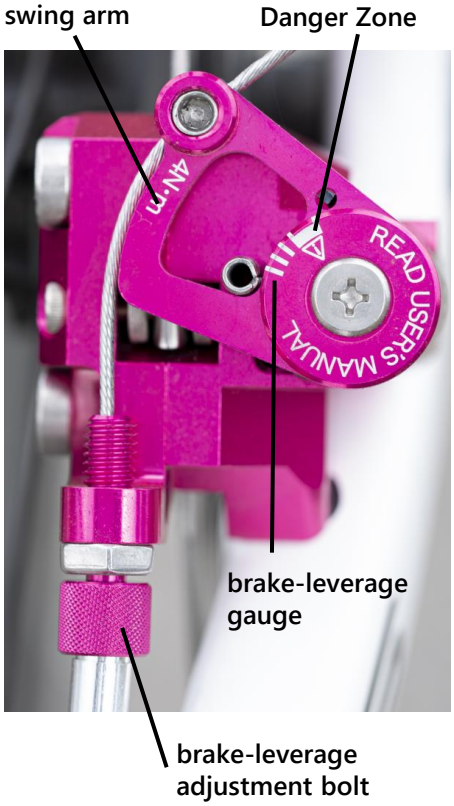
Although there are differences in weight, grip strength, usage, preferences, front and rear brakes, and so on, we have been using the same brakes.
Braking is one of the pleasures if you have a brake feeling that suits you.
EQUAL has achieved the world's first brake-leverage adjustment function with its vertical cam structure (according to our research).
The brake-leverage affects the force with which you pull the brake lever and the actual deceleration feeling.
EQUAL can change the force to push the pad (rate of force increase) in relation to the rotation angle by using a cam shape.

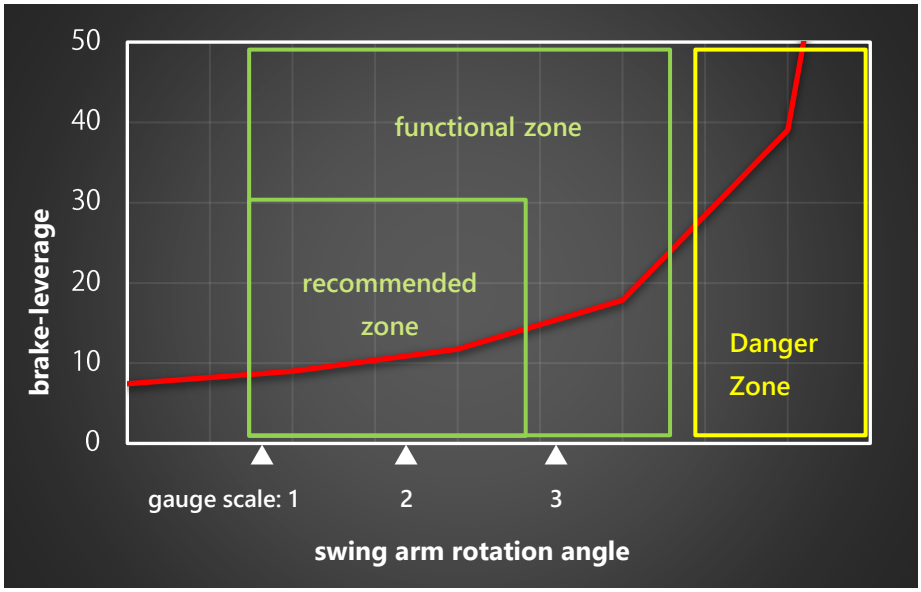
This is how it actually works:
When you grip the lever, the swing arm rotates and the pad hits the rotor.
The rate of boost is determined by the rotation angle (swing arm position) that hits.
After that, even if you squeeze the lever, the swing arm hardly rotates, so the boost rate hardly changes. (Don't misunderstand that the more you squeeze the lever, the higher the rate will be.)
However, as the pad gets worn down, the angle of rotation gets deeper, so the rate of force increase is higher.
It is necessary to adjust the pad clearance frequently.
The rear brake has a longer cable and is less effective than the front, so increasing the rate of force increase in the rear over the front will improve the front-rear balance.
Make various adjustments to find the feeling that suits you.
Please be careful not to enter the Danger Zone.

braking force: low
Braking power rises slowly.
emphasis on controllability

low **brake-leverage** high

braking force: high
Braking force rises quickly.
high initial braking force





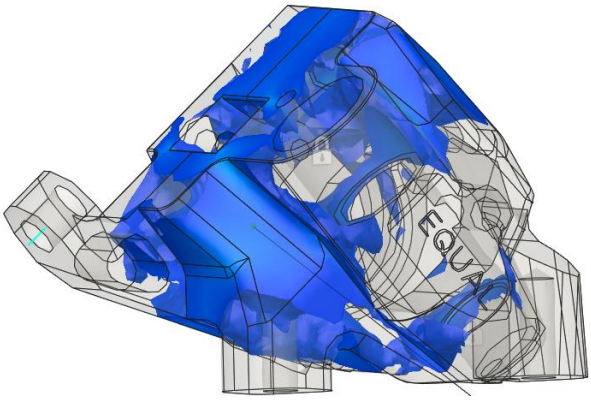
CAUTION: Failure to adjust the pad clearance will result in near Danger Zone. If it enters the Danger Zone, the brakes may not work.

✓World's lightest class mechanical disc brake

We have dispelled the common belief that mechanical systems are heavy.
Compared to the hydraulic system, the cable set is heavier, but does not require a master cylinder.
(Reference value: hydraulic hose weighs 1g/10cm, EQUAL weighs 6g/10cm. This is about the same as a normal mechanical system.)
The brake system and total weight are roughly the same as Shimano's hydraulic Ultegra and GRX. In the case of drop handlebars, the elimination of the master cylinder at the tip of the bike makes the bike feel lighter than its weight.
Also, for mechanical shifting, the lever is more compact.

Achieving both lightweight and high rigidity

It is very difficult to reduce the weight of a mechanical caliper, which consists of many parts, to the same level as a hydraulic caliper.
Therefore, we created several patterns of parts with different shapes and rigidity, conducted evaluation tests, and quantified the required rigidity for each part.
Based on these numerical values, we repeatedly conducted structural analysis simulations using CAE to optimize the shape and remove unnecessary excess weight.
In addition, we used high strength super duralumin as the material and machined almost all the parts of the caliper with high precision.



Weight chart for major disc brake calipers

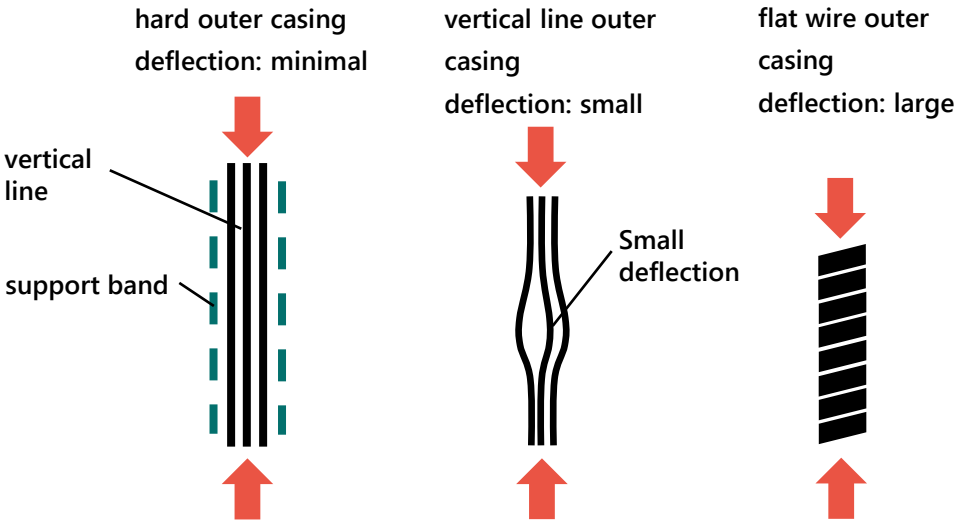
According to our research, as of April 2021. Per one caliper.

manufacturer	name	model	type	weight(g)
Campagnolo	Super Record 12		hydraulic	115
Shimano	Dura-Ace	BR-R9170-R	hydraulic	123
SRAM	RED ETAP AXS		hydraulic	124
Campagnolo	Chorus 12		hydraulic	127.5
GROWTAC	**EQUAL**	**DBR-X0501-SL**	**mechanical**	**136.5**
Shimano	105	BR-R7070-R	hydraulic	138
Shimano	GRX	BR-RX810-R	hydraulic	138
Shimano	Ultegra	BR-R8070-R	hydraulic	138
Shimano	GRX	BR-RX400-R	hydraulic	143
TRP	SPYRE SLC FLAT MOUNT		mechanical	146
TEKTRO	LYRA		mechanical	148
Shimano	Tiagra	BR-4770-R	hydraulic	150
TRP	SPYRE FLAT MOUNT		mechanical	154
TEKTRO	MD-C550		mechanical	155
Shimano	XTR	BR-M9100	hydraulic	156
SRAM	RED ETAP AXS		hydraulic	158
Shimano	Shimano	BR-CX77	mechanical	159
SRAM	FORCE ETAP AXS		hydraulic	166
SRAM	AVID	BB7 ROAD SL	mechanical	170
Shimano	XTR	BR-M9110	hydraulic	170.5
SRAM	FORCE ETAP AXS		hydraulic	180
Shimano	SORA	BR-R317	mechanical	183
Shimano	XTR	BR-M9120	hydraulic	192.5
SRAM	AVID	BB7 ROAD S	mechanical	197

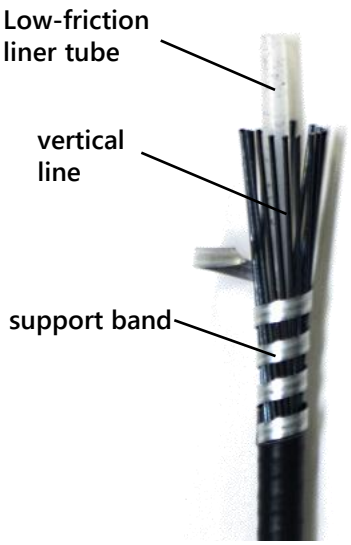
✓High efficiency hard outer casing

We reviewed from the ground up the brake cable, which is very important because it transmits the power input from the brake lever to the brake caliper.
The current brake cables are optimized for rim brakes and do not perform well with mechanical disc brakes. In particular, they are vulnerable to compression forces applied to the outer casing.
For this reason, EQUAL uses a hard outer casing that is resistant to compression.
Compared to the conventional flat wire type for rim brakes, we have achieved a transmission efficiency of approximately 200%.
The inner cables are 19-wire slick inner cables made by NISSEN*.
It enables smooth braking without roughness.

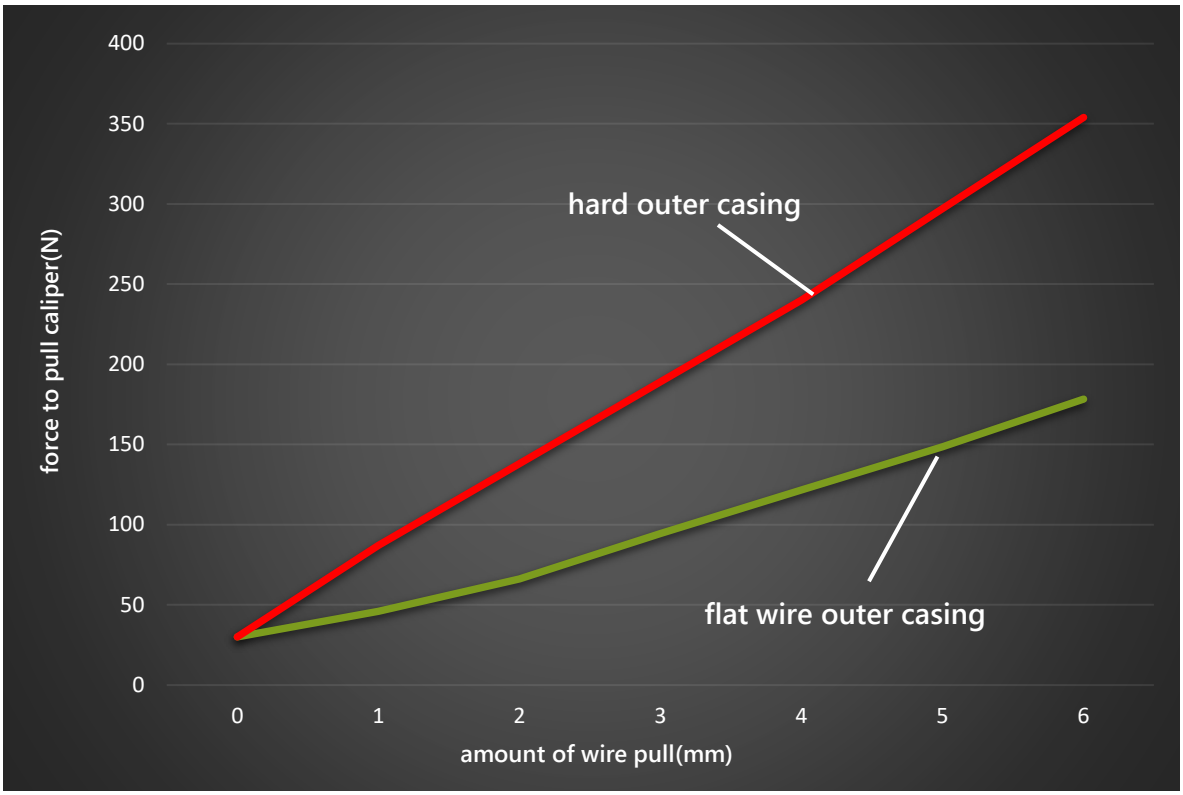
*A Japanese manufacturer of bicycle cables and other products (https://www.nissen-cable.jp/).



The vertical line alone has sufficient performance, but it is reinforced with a support band to reduce deflection.



structure of hard outer casing



NOTE: The hard outer cannot handle small bend radius. Where small bending radius is required, the included soft outer must be connected to the connector for routing.
The higher the rate of use of the hard outer, the higher the transmission efficiency.
On frames with fully internal cables, the hard outer may be used less.

✓Dedicated brake pads (Shimano road compatible) engineered by Vesrah

In order to achieve the brake feeling required by EQUAL, it was jointly developed with Vesrah*, which has high technological capabilities.
It has high braking force and wear resistance, and the base plate is made of aluminum, which has high heat dissipation and is lightweight.
(The shape is compatible with Shimano's road bike pads.)
With disc brakes, the pad makes a big difference in the brake feeling.
The background of the joint development is that Vesrah's many lineups are in line with the EQUAL concept.
It is very fun to choose a pad based on your use and preference, so please try out different ones.
Bicycle Pads - Vesrah Company, Inc. (http://www.vesrah.tokyo/bicycle-pads/)
*A Japanese manufacturer specializing in brake pads. Especially in the aftermarket of brake pads, it is highly evaluated.

Vesrah®

✓Other features: Stepless independent brake pad adjustment mechanism

Most mechanical disc brake calipers have a stepped pad adjustment screw, such as 6 steps per revolution. However, the pad clearance is so severe that it is difficult to get the adjustment just right.
In some cases, the outer clearance adjustment is also combined with the wire adjustment screw. If the inside and outside adjustment methods are different, the sensation will be different, and it can take time to adjust.
EQUAL's stepless pad adjustment screw allows you to adjust the pad clearance perfectly.
In addition, the same method of adjustment is used for both the inner and outer sides of the pad, so adjustment can be done with the same feeling on both sides.
Since this is a part that is adjusted on a daily basis, we put emphasis on the sensation and ease of understanding.

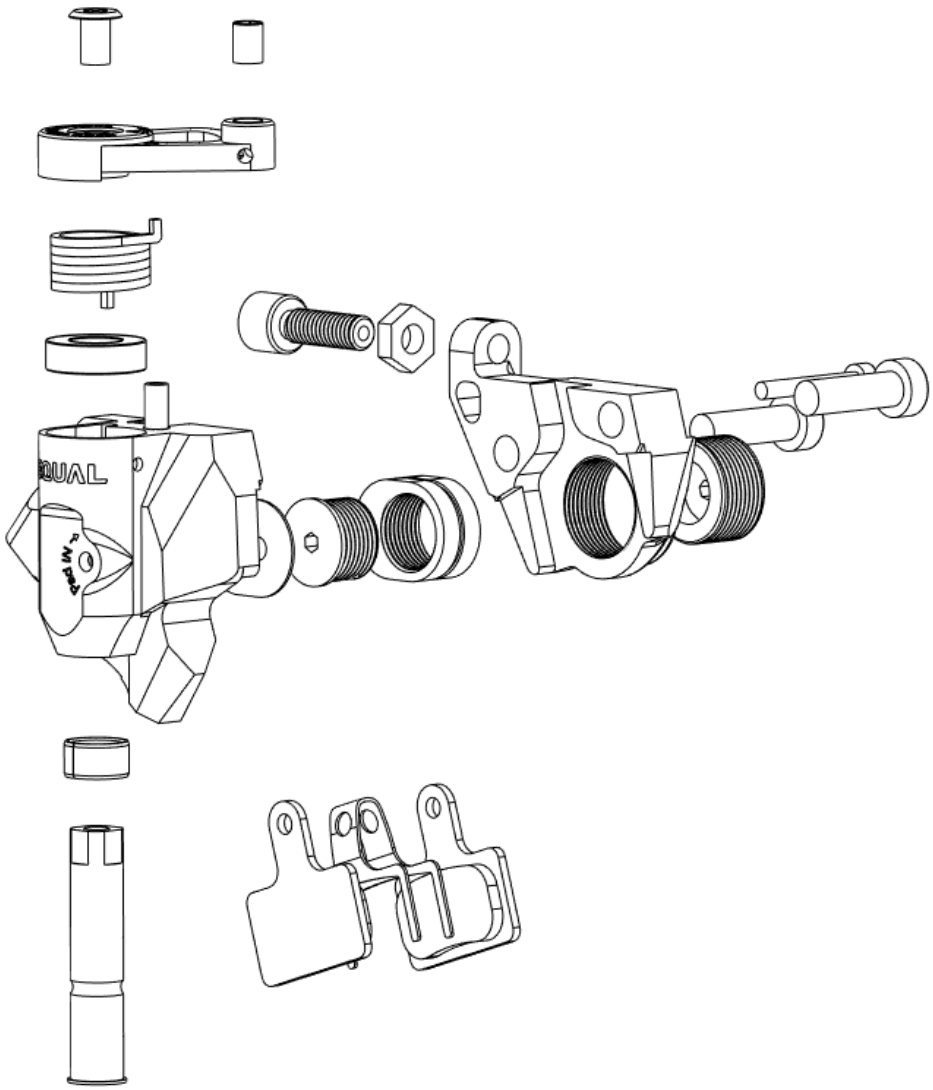
✓Other features: Disassembly and maintenance

Some mechanical disc brake calipers from other companies cannot be disassembled and maintained.
EQUAL can be disassembled and maintained* so that it can be used for a long time with stable performance.
*Please follow the dealer manual for disassembly and maintenance. Please ask a professional store to do the work.

✓Other features: Selectable colors

The color that suits your bike best.
Adding a small color to the center of the wheel will greatly change the image of the bicycle.
EQUAL has 4 regular colors and 1 special color. (As of August 2021)

Exploded view



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