

The Blade Geometry FAQ

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What changed: Cleaned up the Bellies & Angles section, now using the term "positive included angle" instead of "forward rake"

Contents:

- I. Introduction to the Blade Geometry FAQ
- II. Blade Characteristics
 - The Belly
 - The Re-Curved Belly
 - Bellies and Angles
 - The Point
 - Blade Thickness
 - Edge Thickness
 - The Primary-Bevel Edge
- III. Blade Grinds
 - The Hollow Grind
 - The Chisel Grind
 - The Sabre Grind
 - The Flat Grind
 - The Convex Grind
 - The Dual-Ground Reinforced Tanto
- IV. Blade Shapes, and What They're Good For
 - The Clip Point
 - The Drop Point
 - The Tanto
 - * Americanized Tanto
 - * Chisel-Ground Tanto
 - The Sheepsfoot
 - The Dagger
 - The Spear Point
 - The Trailing Point
- V. Steel and Blade Geometry
- VI. Putting It All Together
 - Two Combat/Utility Knives
 - The Camp Knife
 - Three Folders
 - A Hunter (Classic Loveless and A.G.R. Deerhunter)
 - A Custom-Made Folder

I. Introduction to the Blade Geometry FAQ

Welcome to the blade geometry FAQ. Our objective is to provide a working knowledge of blade shapes and grinds. After reading the FAQ, I hope you'll be better able to answer the question, "I need to do job X, what kinds of knives should I consider?". We will start with some general characteristics of blade shapes, then talk about blade grinds, then put it all together to discuss specific blade patterns. The last

section, a brief analysis of some common designs, will build upon the previous sections. It's important to keep in mind that the characteristics can be as important as blade shape. When you're done with the FAQ, you should be able to make decisions not only on blade shape but on other attributes. If you need to slice, you'll know to look for a nice curving belly -- and not get hung up on what the ostensible blade shape is supposed to be.

II. Blade Characteristics

- The Belly

The belly of a blade is the curving section under the point. Some knives do not have a curving section (e.g., Americanized tanto), others are mostly curve (e.g., skinner). The belly increases the knife's ability to both slice and slash. It presents an ever-changing angle to the material being cut, and this means slicing efficiency is preserved across the cut.

If slicing and slashing are important to you, you want to look for a nice curving belly. However, there are always tradeoffs. Typically, the more belly a knife has, the less acute its point. So you get better slicing, but piercing ability goes down. A knife with tons of belly is the Emerson Commander (which actually has a recurved belly), and you can see the point on this knife is not very acute. Trailing point skimmers are basically all belly, because you do nothing but slice with them. A knife with little belly is the classic F-S dagger, and this knife has an incredible point for piercing but is not a great slicer/slasher.

So you trade off belly (slicing) for point (piercing). There are some games that can be played here. For example, if the knife design has lots of belly for slicing, the designer can clip the point and add a false edge to make it a bit sharper.

- The Re-curved Belly

When the belly of the knife is S-shaped, it is called a re-curved belly. The Emerson Commander has a very sharp re-curve, so does the Cold Steel Vaquero Grande. The Darrel Ralph Krait has a more subtle recurve.

The recurved belly presents more edge to the material being cut, and in slicing forces the material into the edge. It is an even better slicer/slasher, and in a big knife (see some of Walter Brend's knives), can make for excellent chopping geometry as well.

The downside of this design is that it is *very* difficult to sharpen. Freehand on a big stone, it's nearly impossible. Some of the sharpening rigs available make the job easier, but in any case it's still difficult.

- Bellies and Angles

Another way to improve edge angles without introducing the hard-to-sharpen recurved blade is by playing with the angles between

the edge and handle. One way to do this is with a positive included angle. This means that if you're holding the knife in your hand, spine parallel to the ground, the knife's edge is *not* parallel to the ground, but rather angles down toward the ground (from handle as it goes towards the tip) before it goes up towards the tip. Another way to say this is, the edge at its lowest point is below the handle, and must angle back upwards to meet the handle. This provides more edge for the blade size. The Mad Dog ATAK is a knife with a positive included angle. The BM spike shows the opposite -- a negative angle -- where the edge just goes straight up towards the tip right from the beginning. A positive included angle generally provides more edge and belly, a negative one provides a sharper point.

Another method to change the angles is to join the blade and handle at an angle. This can change the ergonomics for the better on some designs.

Both methods exaggerate the angle change for slicing, slashing, or chopping, and this in turn increases performance. The chopping ability of the kukri, the chopping/slashing/slicing ability of the ATAK, and the slicing ability of the AFCK are due in part to belly angles.

- The Point

The point is, obviously, what the knife pierces with. Like everything else, designing the point is a game of compromises. To pierce really well, there needs to be as little metal as possible up front, so a piercing point is thin and incredibly sharp. The downside is that the sharper the point, the weaker it is.

For some designs, like a dagger, the objective of the design is to pierce. So a dagger has a thin point, sharp on both sides to decrease the profile and to enable the knife to cut its way in from all sides. Other designs, like the skinner, put the point up and out of the way since the objective of the design is to slice. The Americanized tanto has a very strong point, due to the spine being full thickness very close to the point. This means it won't penetrate anything like a dagger into a soft target, but the massively strong point can survive a thrust into a very hard target that would break a dagger point.

Some tricks can be employed to make the point stronger (and worse at piercing) or sharper (and weaker). A false edge can be ground into a point to make it pierce better, for example.

The other important decision about the point is where to put it. It can be placed to provide a number of characteristics. Some knives place the point down almost at the edge. For example, the Japanese-style chef knife, the santuko, has this format. The knife is used to chop food and do long slices, so a low point means maximum straight edge length. The trailing point hunter, which is used for slicing in a way which requires a belly, puts the point way up high and out of the way. Knives whose points require maximum control -- a hunter used for dressing out game, or a defensive knife -- want the point to be in line with the users hand. This usually means the point must be below the spine of the blade. There are a number of methods to achieve this, such as dropping the point in a convex curve (drop

point format), a concave curve (clip point format), or straight line (still called a clip point, usually).

- Blade Thickness

Blade thickness or thinness is important to both strength and cutting ability of the knife. A thick blade will generally be stronger. But a thin blade will generally have a thinner edge -- and thin edges cut easier and better. So the choice of blade thickness is driven by the compromise of strength vs. cutting ability, just like the choice of point type.

Once the blade thickness is chosen, the particular grind type (see below) can reinforce the attributes of that thickness, or try to make up for any weakness. For example, on a thick blade, a flat or hollow grind can be utilized, so that even though the spine is thick & strong, the edge is thin and cuts a bit better than expected. Or on a thin blade, a sabre grind can be used to make the edge a bit stronger than it would otherwise be. Of course, the grind can reinforce rather than counteract the blade thickness. For example, on the AG Russell Deerhunter, the flat grind is done on a thin blade, to make for exceptional cutting ability, but the design lacks weight for chopping and strength for prying, being exceptionally thin.

- Edge Thickness

The thickness of the edge is another tradeoff in strength vs. cutting ability. The thinner the edge, generally the better it will cut, but a thin edge is weak and can chip out or roll over faster than a thick edge. A thick edge is strong, but doesn't cut as well.

The blade shape, plus the thickness of the blade spine, combined with the grind type, determines the edge thickness.

The edge thickness is one of the only factors that can be modified easily by the knife owner (rather than the maker). Remember that if you're not happy with the way a knife is performing, there's no reason you're stuck with the factory edge. Feel free to re-sharpen, grinding a lower-angle thinner edge into the knife. At some point, if you go too thin the edge will start chipping out, that's an indication that you need to thicken the edge back up. Also see the Sharpening FAQ.

- The Primary-Bevel Edge

Normally, a knife has two bevels. If you look at, say, a Kabar, you will first see a bevel at starts from the middle of the knife and goes most of the way towards the edge. I'll call this the primary bevel. Then at the very edge itself, there is *another* bevel. at a higher angle, that forms the actual edge. I'll call this the secondary bevel. Most knives have this kind of geometry, where a shallow primary bevel meets a bigger secondary edge bevel. This leave the edge a bit thicker for robustness.

However, some knives do not have a secondary bevel to form the edge. Scandanavian knives, like the Finnish puukko, only have a single bevel. So ostensibly, the puukko is a sabre grind (see below). However, because the primary bevel goes all the way down to the edge,

the edge ends up being a thin high-performance edge rather than a thicker stronger edge. Combined with the normally thin blades on the puukko, the edge ends up being thin enough to cut really well.

Similarly, some chisel-ground knives also feature a primary-bevel edge. Again, it guarantees thinness and sharpness at the edge. The most popular chisel-ground folder, Benchmade's CQC7, has an edge that is formed by a secondary bevel. However, many other chisel-ground knives do not have the secondary bevel.

III. Blade Grinds

- The Hollow Grind

The hollow grind is done by taking two concave scoops out of the side of the blade. Many production companies use this grind, because it's easier to design machines to do it. But many custom makers grind this way as well. Its great advantage is that the edge is extraordinarily thin, and thin edges slice better. The disadvantage is that the thinner the edge, the weaker it is. Hollow ground edges can chip or roll over in harder use. And the hollow ground edge can't penetrate too far for food-type chopping, because the edge gets non-linearly thicker as it nears the spine.

For designs where slicing is important, but the slice doesn't need to go too deep, this grind is an excellent choice. Many hunting knives are hollow ground, because field dressing is often best done with a knife that slices exceptionally well through soft tissues. Unfortunately, if you hit a bone, you can chip the edge, so the flat grind (see below) is also used often.

Another advantage of the hollow ground knife, at least at the beginning, is ease of sharpening. Most hollow grinds thicken slightly towards the edge. That means that as you sharpen (at least at first), the blade gets thinner and easier to sharpen. After this, however, the blade begins thickening non-linearly and sharpening will become more difficult.

The ultimate push cutter, the straight razor, is usually hollow ground.

- The Chisel Grind

The chisel grind is a knife which is not ground at all on one side. So it is completely flat on one side, and has a bevel on the other. It is simple to produce (the maker need only grind one side), and simple to sharpen (it is sharpened on one side only, then the burr is stropped off the other side). It is also typically very sharp, due to the single bevel design. Whereas a blade ground on both sides might be sharpened at 20 degrees per side, for a total of 40-degrees edge angle, a chisel ground blade is often ground at around 30 degrees, making for a thin (and thus sharp) edge.

Accurate slices are very difficult with the chisel grind, due to the fact that the non-symmetrical design forces the knife to curve in the medium being cut.

- The Sabre Grind

The sabre grind is a strong edge format. The bevel starts around the middle of the blade, and proceeds flatly towards the edge. This leaves a strong edge for chopping and other hard use. But it also means the edge will be fairly thick, so this design will not necessarily slice all that well.

The thickness of the sabre grind does have an advantage in certain chopping applications, however. A thinner flat-grind knife will often penetrate deeply into wood but stick badly, reducing chopping efficiency. A sabre grind has enough wedge to keep from sticking, and combined with the edge strength of a sabre grind, this makes it an excellent candidate for hard chopping tools.

The sabre grind is found on many military classic designs such as the Randall #1 and the Kabar.

- The Flat Grind

The flat grind endeavors to provide an edge that is both thin and strong, and leaves a strong thick spine. The grind is completely flat, going from the spine to the edge. This grind is harder to make, because a lot of steel needs to be ground away. However, the edge ends up being fairly thin and so cutting very well. Because the bevels are flat, there is plenty of metal backing the edge, so it's much stronger than a hollow grind. It is not as strong as a sabre grind, but will out cut that grind.

The edge on this design also penetrates better for slicing and chopping. The hollow grind expands non-linearly as you go up the blade, the sabre grind expands linearly but very quickly. The flat grind expands linearly and slowly. Kitchen knives are usually flat ground, because when chopping/slicing food you need to push the blade all the way through the food. This grind is an outstanding compromise between strength and cutting ability, sacrificing little for either.

- The Convex Grind

Also called the Moran grind, after Bill Moran. This grind is as you would expect, the grind arcs down in a convex curve down to the edge. This means the point can be very sharp, because there's no secondary bevels to create the edge itself, just two intersecting arcs. There is also a fair amount of steel behind the edge, because the convex arcs cause the edge to widen non-linearly. This is a strong-edge format, which won't penetrate like a flat grind but will be stronger. Knifemakers form this grind on a flat-belt grinder. A disadvantage of this grind is if you don't have a flat-belt grinder yourself, it is difficult to touch up the edge.

- The Dual-Ground Reinforced Tanto

The Americanized tanto as executed by Cold Steel shows multiple grind types. Along the long flat, the knife is hollow ground, for a thin edge and incredible sharpness. However, along the front up to the point, the grind switches to a flat grind. This provides incredible

tip strength. The result is a knife with a very keen bottom edge, but a strong profile towards the front where it pierces. Of course, the reinforced front edge is strong but doesn't pierce easily.

IV. Blade Shapes, and What They're Good For

- The Clip Point

A great all-around format and one of the most popular, it's used on everything from the famous Buck 110 folder, to the Randall #1 fighter, to most bowies. The format has a concave or straight cut-out at the tip (the "clip"). This makes the point sharper, and also lowers it for more control. Clip point blades usually also provide plenty of belly.

The tip is controllable and sharp, and the belly provides good slicing/slashing, and so this format is popular on formats from utility knives to camp knives to fighters to hunting knives.

- The Drop Point

Another great all-around format, this pattern is used on many knives but is most popular on hunters. The tip is lowered (dropped) via a convex arc from the spine. This lowers the point for great controllability. The point retains great strength. Most drop point patterns also retain plenty of belly.

Due to the very controllable point, this pattern is very popular on hunting knives, where it's important to keep the point from nicking an organ. The inclusion of plenty of belly makes it a good slicer and slasher. This format is also popular on utility knives and even fighters, where the strong point can hold up to heavy use. The point on a drop point usually won't be quite as sharp as that on a clip-point, but will be stronger.

- The Tanto (Americanized and Chisel-Ground)

The Americanized tanto, popularized by Cold Steel, is usually dual-ground for point strength and sharpness along the straight edge. The point is directly along the spine. The front edge meets the long straight edge at a sharp angle, forming the "secondary point". The blade is often dual-ground, with a hollow grind along the straight edge, and a flat grind of sorts up front.

The point on this format is incredibly strong, due to the spine keeping its full width until very close to the point, and then a strong flat grind being used to create the point. There is a lot of metal up front at that point, which makes this format not the best piercer into soft materials, but incredibly strong and able to survive thrusting into very hard materials. The high point also provides less control than the drop- and clip-point formats.

The hollow ground straight edge is very sharp. There is no belly per se, so slicing can be awkward, and this is not the best format for general utility use since a belly is so useful for that. For hard use where a very strong point is needed, this format is exceptional. The

very sharp hollow-ground straight edge performs very well for any job that doesn't require a belly. For slashing, the promoters of this format claim the secondary point positively reinforces the slash, so even though the design is bellyless it still slashes well.

A hot trend today is chisel-ground tantos. These knives usually have a basic Americanized tanto shape, often with the point clipped. But it is ground on one side one, usually a sabre grind (rather than the dual-ground Americanized tanto popularized by Cold Steel). Many chisel-ground tantos have one a single bevel to the edge, with no secondary bevel to form the edge itself, which leaves the format very sharp. Aside from the lack of belly, the non-symmetrical grind makes this type of knife difficult to cut straight, making it even less useful for general utility. The extremely thin edge cuts well for shallow cuts, but the edge usually reaches full spine thickness relatively quickly, so deep-cutting performance can suffer.

I have not discussed the classic Japanese tanto shape, because that design is not seen much in everyday cutlery.

- The Sheepsfoot

The sheepsfoot blade really can't be said to have a point. The spine curves down to meet the edge. The objective of this format is to provide an edge that can be used for cutting, while minimizing the chances that anything delicate will be accidentally pierced by the point. For example, it is marketed to emergency personnel, who may have to cut a person out of their seatbelt at an accident scene, and don't want to risk stabbing the victim in the process. Also this pattern is popular among sailors, and the explanations here vary depending on who you talk to. It may be because when their knife is out, the sailors don't want to risk accidentally puncturing a sail. Or, as the legend goes, it may be because when sailors have pointy knives, they end up stabbing each other with them. Pick your fave.

The Japanese style chef's knife, the Santuko, also is close to this format, though the belly on that knife curves slightly. There's no need for a point for the usage of this knife, so the dropped point maximizes the straight edge length.

- The Dagger

The dagger's format provides the ultimate in piercing soft targets. The format tapers to a very thin very sharp point, which pierces easily and deeply into soft targets, but is weak and can (and does) break on hard targets. The dagger usually has two sharp edges, to reduce the profile and let the knife cut in on both sides.

The dagger usually has little or no belly per se, instead tapering in relatively straight line towards the point, though you will see great variations in the degree to which there's a curve towards the point. In addition, both edges are ground from the exact center of the blade. The geometry, between the lack of belly and the quickly-thickening edges, is not good for slicing/slashing.

- The Spear Point

A "real" spear point is what you would find on a spear -- point exactly in the center of the blade, both edges sharpened. But when knives are described as "spear point", this describes a special case of a drop point. In a drop point, the point drops slightly from the spine of the blade. In a spear point, the point drops all the way to the center of the blade. Point controllability is excellent, and the point is strong (but dull if not double-edged), and with the point so low the belly is rather small.

- The Trailing Point

The trailing point format has a point that's as high or higher than the blade spine, and a big long curving belly. The belly is the objective of this format, and it's used for jobs where slicing is the most important function. It is very popular on skinning knives, where lots of belly comes in handy for slicing. The point is high and out of the way, it may function slightly as a piercer, but on some trailing point knives the point is nonfunctional.

- The Hook Blade

The edge on a hook blade curves in a concave manner. This type of knife was traditionally used for gardening, and it has gained some acceptance for utility use. For shallow slicing, the material to be is place on the edge near the handle. As the knife is pulled, the geometry of the curve forces the material into the edge nearer the tip, and slicing performance is good. Or you can just pierce material with the tip and just pull the knife, the edge will function the same way. This format works well as a slicer when you can get the material positioned in the "sweet spot" of the curve (e.g., pruning). This basically means the material to be cut needs to have a smaller radius than the blade itself, so hook blades work well for pruning but would have a harder time slicing a tomato.

V. Steel and Blade Geometry

Does the blade geometry have any affect on the steel used? Well, indirectly. In theory, the blade geometry is designed for a certain function, and the steel chosen will also be one suited for that function. This doesn't mean there's an obvious answer as to which steel should be used on which knife -- quite the opposite, there are almost always lots of different steels that will work well for a particular knife. But understanding the strengths and weaknesses of both the blade geometry and the steel will help you decide which combinations you desire.

For blade geometry, we're often playing off cutting ability versus toughness. For steels, we're playing off toughness versus edge holding versus stainlessness versus sharpenability.

For a salt water dive knife, we may choose a cheap stainless steel (which are usually *very* stainless due to low carbon content) over a high-carbon stainless or a carbon steel. For a machete, we usually choose an inexpensive carbon steel, for economic and functional reasons. Economically, the machete is meant to be an inexpensive tool, and the inexpensive carbon steels are cheap, available, and easy

to work. Functionally, we have a thin-bladed machete, so we need all the toughness we can get; also, we get easy sharpenability.

VI. Putting It All Together

Okay, now we know the characteristics, grinds, and blade shapes, and what they are all good for. If you understand this, you can begin to see how to mix and match features to fine-tune a knife for the functions you want. For example, you may want a tanto, but are willing to sacrifice some of the point strength for control and piercing ability. Having read the FAQ, you know you can clip the point (controllability) and thin the edge via a false edge (piercing ability), which is exactly the approach Benchmade took with their Stryker. Or if you want your tanto to slice a bit better, you can make the straight edge slightly convex to simulate a belly -- the approach taken by Microtech on their SOCOM tanto. By mixing-n-matching, we can enhance a design's strengths or sacrifice a little to make up for a deficiency somewhere else.

With that in mind, let's briefly examine some popular knife designs, and see if we can figure out why the designers made the choices they did.

- Two Combat/Utility Knives

The Marine Corps' Kabar combat/utility knife is a classic. It's a clip point design, with a false edge that is sometimes sharpened. This makes the point very sharp, and easy to control in thrusts. As with most clip points, there is a nice belly for slicing. This makes it suitable for fighting and utility uses.

The grind chosen was a sabre grind. This makes the edge very strong, but sacrifices cutting ability (versus a flat grind). In theory, the sabre grind might have been chosen because of the very hard use and abuse this knife may go through, not just as a knife but as a pry bar or hole digger. At least as importantly, the sabre grind is faster and cheaper to produce than a flat grind, important when many knives have to be turned out.

The Mad Dog ATAK takes a different route, going with a thick spine and flat grind, but retaining the clip-point format. The flat grind means the edge will out cut the Kabar, and the thick spine helps assure robustness for hard use (as does the differential heat treatment). A positive included angle (also discussed above) enhances chopping and slicing performance. Sort of a high-performance version of the standard combat/utility knife, more expensive to produce but outperforming the standard in just about every other category.

- The Camp Knife

Camp knives are generally big, 8" or more. They're almost always flat ground, for good edge performance. The job of this kind of knife is to do camp chores, from chopping limbs to splitting kindling to food prep to anything else. The flat grind provides great performance, and the usual clip- or drop-point format provides point control when needed. Size and weight is needed for chopping effectiveness.

- Three Folders

The tactical folder craze has spawned many folders with sabre grinds, and that emphasizes strength over cutting ability. But there are a few folders that consistently do very well in cutting tests.

The Sebenza had a straight clipped point, for excellent control, and plenty of belly. A very high hollow grind provides a thin edge, for great push-cutting and slicing.

The AFCK has a sabre grind, but still performs wonderfully. The blade is relatively thin, so even with the sabre grind the edge remains fairly thin and performs well. In addition, the blade is at an angle to the handle, providing even better slicing and slashing performance. The straight-clipped point is very sharp and controllable.

These two folder makers have made different design decisions, but both have achieved excellent results. The main objectives -- a working point, a belly, and a thin edge -- are achieved through different designs.

The Microtech SOCOM tanto is another design worth examining. It is ostensibly an Americanized tanto. However, the designers have made a large number of interesting tweaks to enhance the design. First, for point control, the point is clipped slightly and the blade meets the handle at an angle -- both of these things bring the point in-line for control. To make the point a better piercer, the front bevel is at a much smaller angle to the point than is normally seen. The normally straight edge is slightly curved, and combined with the low-angle front edge, the secondary point ends up not very sharp. So this is a tanto with a bit of a belly, and combined with the blade/handle angle, functions well as a slasher/slicer. Lastly, Microtech ground in false edge bevels on the spine, which disappear near the point. This leaves the point full width for strength, but removes some weight (and adds good looks) along the spine.

- A Hunter

A.G. Russell's Deerhunter is a drop-point format, and is flat ground like many hunters, to provide a thin edge that cuts exceptionally well. To improve the geometry even more, the spine is $<.125"$, making the entire package extraordinarily thin. As a result, the knife wouldn't be a great choice for prying, but for slicing and push-cutting it is outstanding.

- A Custom-Made Folder

To show the kind of tweaking that can be done, I will describe a custom folder I had made for me by Allen Elishewitz. The blade has the dual-grind of a tanto. That is, flat grind up front near the point, hollow grind along the straight edge. However, this knife is not a tanto, it is a drop point. So this knife has the tip strength of a tanto, but the useful belly of a drop point, and a dropped point for better control. In addition, the point has false edge bevels ground in, which makes it penetrate a bit better. In short, we took

the massive point strength of a tanto, but ground it on the more useful utility shape like a drop point, then ground in bevels to make piercing ability a bit better. Tweak and tune!