

Why Single-Bevel Broadheads?

Because *Rotation* equals *Penetration*!

By Dr. Ed Ashby

Single-bevel broadheads are hardly new to the bowhunting scene. Harry Elburg was the first in modern times to manufacture a single-bevel; his original Grizzly hit production some three decades ago. But millennia before Harry's innovation, stone-age hunters were manufacturing single-bevel heads.

During the past 25 years, I've intensely studied broadhead design and how it affects a hunting arrow's terminal performance in big game tissue, having field tested hundreds of different heads in real tissue, dissecting wound channels and looking at results. It's taken me that long to fully comprehend the "how and why" of single-bevel broadhead performance, and the numerous and remarkable advantages it offers to bowhunters. The most obvious *functional* difference between single- and double-beveled broadheads is the rotation single-bevels induce after impact, as the broadhead penetrates.

Everyone knows that arrows rotate in flight, because of the effect of the fletching. Few of us, however, give arrow rotation much thought beyond that. And why should we? When using a double-beveled broadhead, arrow rotation stops at impact and, unless the broadhead is deflected in some way by impact with a hard tissue, such as bone, the arrow and head penetrate straight through an animal without any rotation. Examination of entrance and exit wounds and the intervening wound channels confirm this.

During flight, a typical arrow makes approximately one revolution (360 degrees) for about every 60" of travel. Several times I've measured the rotational rate exhibited for one specific single-bevel broadhead design: a modified Grizzly, the broadhead I use for most of my big game hunting. Upon impact, its single-bevel edges induce *one complete revolution in just under 16"* of soft-tissue penetration through "pure meat."

The modified Grizzly is a hand-altered version of the 190-grain El Grande, narrowed slightly to 1" wide at the back, with a blade length of 3.125", a 25-degree right-hand single bevel, a 30-degree cut-on-impact Tanto tip, and a main-blade angle of attack of 7.4 degrees. Its finished weight is about 170 grains.

Though many people associate the modified Grizzly



Potato pierced with a single-bevel Grizzly, mounted on a free rotating shaft. Note the large torque-induced split, already almost half the potato.

with my ongoing arrow lethality studies, I can't take credit for its design. If you look at Harry Elburg's paper prototypes, you'll see his progression through three conceptual versions. The two "narrow" versions bear extreme similarity in length, width, and profile to the two modifications I commonly make to the production model. And for good reason; all those years ago, when Harry first told me what he felt single-bevels could do, I paid attention!

What effect does single-bevel-induced broadhead rotation have during tissue penetration, and why is it an advantage?

There are several advantages, in fact, but the most obvious is when the arrow impacts bone. The bevel-induced rotation tends to cause *massive* splits and breaks, especially in heavier bone, whereas a double-bevel broadhead simply forces its way directly through, rarely splitting any but the lightest bone. Splitting, rather than piercing bone, has a well-demonstrated and *major* penetration benefit: opening a large channel through the bone significantly lowers drag on the trailing shaft. And as test results document, shaft drag is a *huge* penetration-reducer.

Why do single-bevel blades rotate, while double-bevels



Here are the pelvis bones of a whitetail in which both sides were split by a pass-through, modified 190-grain Grizzly broadhead.

don't? If you happen to have a kitchen knife with a single-bevel edge, give this little demonstration a try. While holding the knife blade absolutely vertical, try cutting a thin slice off a big roast or ham ... or even a sizable chunk of cheese or a big tomato. What happens? The knife blade 'walks' to one side; the side opposite the bevel. In close-up, the cutting edge is deflected by the pressure the meat exerts on the blade's bevel.

Likewise, if a single-beveled knife blade is shoved or stabbed directly into a slab of meat, the blade does not pass straight through. As the pressure against the bevel forces the blade's cutting edge to deviate one direction, the blade's back-edge is forced against the meat in the *opposing* direction — that is, as the cut 'walks right,' the blade's back edge is forced to the left, and so the blade twists.

And here's the critical point: As the blade twists or 'walks' through the meat, *its* surface area exerts pressure *back onto the meat*. Where does this 'reactive' blade pressure come from?

If you can visualize it, it's the *same* pressure the meat applies to the edge-bevel, being transferred back onto the meat. But there's now a difference in the *direction* that pressure is being applied; it's at a right angle to the direction of the knife blade's passage through the meat. If a similar single-bevel is added on the *back* of the knife blade, on the opposite side of the blade's face from the first bevel, the amount of pressure (force) the resultant 'tissue push' generates against the bevels is double what it was for the one single-bevel. Consequently, the force the blade-flat exerts against the meat at a *right angle* to its direction of travel is also doubled.

I'm dwelling a bit here on the source and effect of a single-bevel broadhead's rotation because so few people really understand it. Most folks I've heard from appear to believe the single-bevel slices in and *pulls* the blade to the side. It doesn't. A single-beveled broadhead's rotation is powered by the tissue(s) the blade is penetrating. The blade, with its two opposing (thus complementary) single bevels, pushes against the tissues and the tissues *push back* (resistance force).

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Because the tissue's push on the broadhead's bevel is not met by any tissue push on the opposite side of that same blade's edge, the edge is shoved sideways — just like the knife's blade edge was when it made that walking cut. Since a broadhead is piercing the tissue, and both its edges are being forced sideways (in the same rotational direction), the broadhead rotates as it moves forward.

Finally, as the broadhead rotates, its face (the blade flat) transmits whatever amount of 'push' the tissue generates on the single bevels back onto the tissue. The more force applied between tissue and bevel, the greater the blade's torque, and the greater the splitting force.

Restated in summary: (1) The *tissue's pressure against the single bevel* forces the blade to rotate, producing torque. (2) The entire blade face transmits this force back onto the tissue, but at a right angle to the direction of arrow travel. (3) The less give the tissue has, the greater the pressure/torque generated. (4) The harder the arrow pushes the bevel against the tissue, the harder the tissue's resistance-force pushes back against the bevel and the greater the total pressure generated. (5) The thicker the tissue (up to a thickness equaling the blade's length), the greater the total amount of bevel surface that's in contact with the tissue, and therefore, the greater the total pressure generated. (6) The thicker the tissue, the longer the time of contact between bevel and tissue as the blade passes through, and the greater the total force (torque) generated. (7) The wider a bevel is, the more bevel-area in contact at any given time, and the greater the torque. Bevel angle and blade thickness determines the bevel's width.

The forgoing are important concepts in understanding: (A) how and why single-bevel broadheads split bone, (B) why splits are more common in heavy bones than they are in lighter bones, and (C) why a broadhead's ability to penetrate deeply is so important when it's an extremely heavy bone that needs breaking — a rib on an elk or moose, a scapula on a deer — and why, therefore, high broadhead mechanical (penetration) advantage and heavy arrow weight contribute significantly to the single-bevel bone-splitting physics.

Physics aside, the simple explanation is this: When an arrow tipped with a modified Grizzly or another well-designed single-bevel head passes through bone, the arrow applies force between the single-bevel's taper and the bone. The bone applies a firm resistance back onto the bevel. This induces rotation, which exerts torque; a *twisting* force. The blade face transmits this torque back to the bone, *at a right angle to the arrow's direction of travel*. The deeper the broadhead penetrates into/through the bone, the greater the surface area of bevel in contact with the bone, and the greater the total splitting force generated. When the total applied lateral pressure exceeds the bone's tensile strength ... *Bam!* The bone splits or breaks.

An even simpler explanation is that the bone's pressure against the single-bevel *tries* to rotate (twist) *the entire broadhead* about 70 degrees during its 3-1/8" of travel through the bone. This exerts significant lateral pressure. Try sticking even a very thin knife blade through a bone and rotating it just a few degrees; the bone splits and resistance



This whitetail pelvis clearly shows the torque induced split by the single-bevel head.

to penetration drops instantly and dramatically.

Since the tissue pressure on the blade bevel, which causes the rotation and generates the force used to split the bone, is a result of the arrow's force applied to the tissue, does this mean arrow force is being used up in order to break the bone? Yes, of course. However, breaking a bone in this manner uses *less* arrow force than if the arrow has to push its way directly through the bone with no twist. That's why a single-bevel broadhead *consistently* shows far more tissue penetration *after* passing through the bone than a matching double-beveled broadhead.

And now for a couple of additional "maybes" ... Single-bevel rotation *may* also be tapping into the rotational energy the arrow carries in flight, applying it usefully in breaking bone. A second physical factor that *may* be important is that rotational velocity (and the resultant rotational force) is shed more slowly than linear velocity. For example, during flight, a bullet from a rifled barrel sheds rotational velocity more slowly than it sheds linear velocity, and is still revolving in tissue after all forward motion has ceased!

But regardless of what portion(s) of an arrow's kinetic energy the bone-splitting force is derived from, the *consistent* penetration gain single-bevel heads show over matching broadheads/arrows provides empirical proof that single-bevel broadheads use up less arrow energy and force to breach bones than do matching-profile double-beveled broadheads.

Many who've never closely examined the difference a single-bevel can make to penetration and lethality may question whether broadhead rotation has much effect. The accompanying photos show what the single-bevel does, both in bone and soft tissues, why it works, and the results of its many effects during arrow penetration.

Dr. Ed Ashby was the subject of an in-depth, two-part profile by David Petersen that appeared in the last Dec/Jan 2008 and Feb/Mar 2008 issues of the magazine.



More Questions for the Doctor

By David Petersen

Dave Petersen: Ed, it must be gratifying that after all these years, shooters and the industry are finally paying attention to your research, with several manufacturers suddenly offering, or soon planning to offer, single-bevel "Ashby-style" broadheads.

Ed Ashby: It's a mixed bag. A big fear is that folks will start putting single bevels on heads that don't have suitable metal characteristics, and then they won't get the good results that the tougher Grizzlies have shown, and erroneously attribute the lack of performance to single-bevels not working like the data show. There's much more to it than a single bevel. Maximum single-bevel effects *require* a low bevel angle (I've found 25 degrees to be optimal). It follows that such thin blade edges *require* hard steel. In the photos in the accompanying article, you can envision the amount of abuse the thin blade edges take as they penetrate bone, creating those over-sized holes. If the steel is too soft, it's the broadhead that takes the beating from the bone, rather than the other way around. Soft steel results in rolled edges and bent heads. Even with the lower R hardness versions of the Grizzly, I've had heads bend when the blade was twisted during heavy bone penetration (fairly common with the 125s). All told, we want a low bevel angle on a thick blade made from steel hard enough to support the thin edge without curling or bending. My hope is that one or more of the several good broadhead manufacturers currently experimenting with single-bevels will produce a head that incorporates *all* the features a high-performance single-bevel requires — strong, hard, hefty, thick-bladed, Tanto tipped, good mass, low bevel angle, at least a 3:1 taper ratio, and Teflon coating. A reasonable degree of out-of-the-package sharpness would also be appreciated!

Dave: In your experience and testing, what have you found to be the ideal broadhead steel?

Ed: I've always preferred high-carbon steel with a Rockwell hardness of *at least* R52. I've worked with up to R62, which is still not so hard that it becomes brittle to the point that edges shatter on impact with bone. The 190 Grizzly ranges from R52 to R54 on every batch I've had tested. Until I worked with Silver Flames, I'd never encountered a stainless steel in any broadhead that showed suitable performance. The Silver Flame blade is 440B stainless, and is the finest production broadhead steel I've seen. Hardness is R57-58, which I'd say is about ideal. Finally, they are cryogenically treated, which de-stresses the steel to make it less brittle.

Dave: I've checked out the Silver Flames and see sev-

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eral problems. They're outrageously expensive (about \$25 each), double- rather than single-bevel, and available only as screw-ins. And don't the big vents in the blades and the screws projecting from the ferule give them the "bumpy" penetration disadvantage you've spoken of before? And what about mechanical advantage, etc.?

Ed: Your concerns are spot on. My praise is reserved for the Silver Flame's *steel quality*, which is the finest stainless I've seen. From a practical viewpoint, a good, high-carbon tool steel, at somewhere in the R57-58 hardness range, would be about ideal, far less expensive, and capable of doing all we could ask of a broadhead, especially if we give it a quality Teflon coating.

Dave: One of the most common justifications I hear from hunters for not using traditional (double-bevel) two-blade broadheads goes like this: "I want a big, multi-blade head that makes a *big* hole for a good blood trail." In looking at the remarkable photos in the accompanying article — the gaping exit wounds in inch-thick buffalo hide and a deer neck pass-through — it appears that with well designed single-bevel two-blades, we can have our cake and eat it too ... all the strength and penetration advantages that two-blades demonstrate over multi-blades, as well as "a *big* hole for a good blood trail."

Ed: The single-bevel heads frequently give very wide exit cuts. That's because skin is elastic and isn't supported by underlying tissues as the broadhead exits. The skin gets wound up around the blade while the broadhead is cutting through, and the exit ends up wide and L-shaped. Tissue windup is what makes the starburst cuts common in intestinal tissues too. Don't get me wrong; you won't *always* get huge exits with single bevels, but they are common. The greatest aid to recovery, however, is not copious blood but a *short* blood trail, and single-bevels have an outstanding record there, especially on marginal hits. As an aside, we're working hard on collecting blood trail data from different types of broadheads. We have a long way to go before we can reach any solid conclusions, but so far the number of blades shows no clear advantage. The big correlations are: (1) hit location, (2) presence or absence of an exit wound, (3) location of exit wound, (4) what organs were hit during penetration and, (5) the experience level of the hunter reporting. The more experienced the hunter, the stronger average blood trail they report, regardless of broadhead or other factors. Life is full of surprises!



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A Second Opinion

If we didn't know that he lives in Wisconsin, we'd think Ron Kulas was from Missouri, given his "Show me!" attitude. After reading Dr. Ashby work on the effectiveness of single-bevel broadheads for splitting heavy bone, Ron decided to investigate for himself. After fabricating a batch of homemade broadheads roughly approximating the Grizzly in size, shape, and weight, Ron gave them single bevels close to Ashby's recommended 25-degree angle. The finished products weighed 170 grains.



Photo 1. Using a freshly killed, field-dressed whitetail doe as the testing medium, Kulas took three shots from 10 yards, using a 45# homemade wood bow pushing 450-grain wood arrows at 142 fps. The first two shots were rib-cage pass-throughs with no bone encounters.



Photo 2. The third shot hit pay dirt, impacting the shoulder blade at its heaviest point, where the flat and the "T" blend, near the ball joint ... a nightmare shot if ever there

was one, but always a possibility since the shoulder overlies the heart from certain shot angles. Ron's slow-moving, light-weight arrow and homemade single-bevel, while falling well short of Ashby's recommendations for a *big-big* game set-up, nevertheless split the whitetail scapula stem-to-stern while penetrating fletching-deep and exiting the off-side of the deer.



Photos 3&4, above and below, respectively. "Both the hide and the shoulder meat showed the gaping, S-shaped wound channels Dr. Ashby describes for single-bevels," Ron reports. "This was the case for both entrance and exit wounds on all three shots." These findings confirm that the twisting induced by the single-bevel head passing through tissue, as described in the accompanying article, persisted *throughout* the arrow's forward movement. "Everything I'd read from Dr. Ashby was proven right before my eyes," Kulas concludes. "Even with smallish big game animals like this little whitetail doe, the extra bone-splitting and consequent penetration advantage of single-bevel heads can make a *big* difference in recovery success with heavy-bone hits, especially for those of us who shoot relatively light, slow traditional bows."

—David Petersen

