Guidewire Selection for Peripheral Vascular Interventions

Understanding the design elements of interventional guidewires is the basis for successful use.

BY CRAIG WALKER, MD

Guidewires are an integral part of vascular intervention. They are utilized to access target vessels, cross lesions, and deliver definitive interventional therapy. There are many choices in guidewires, as different clinical presentations require different device attributes (Figure 1). Selection of an appropriate guidewire can improve crossing success (particularly in total occlusions), improve device delivery, limit cost, and limit the risk of vascular injury either from the distal wire tip or wire shaft buckling.

Deciding which device attributes are needed in individual cases requires knowledge of engineering concepts that create those attributes. In certain cases, one wire may be needed for crossing and then exchanged in order to achieve better or safer device delivery. Intraluminal crossing requires different techniques and device attributes than subintimal crossing. With proper wire choice and manipulation, the overwhelming majority of occlusions can be crossed and treated interventionally without the need for more expensive dedicated crossing tools. This article breaks down the basic building blocks of guidewires and how to select and optimize use of the right type.

CORE DIAMETER

The core diameter is the functional diameter of the guidewire. In peripheral intervention cases, the most widely utilized sizes are 0.014, 0.018, and 0.035 inch. Larger-diameter wires have greater rail support, as the strength is related to the radius^4 (Figure 2). A larger diameter improves torque and can be used to straighten vessels (eg, sheath placement in a tight iliac bifurcation). Smaller diameters have increased flexibility and trackability through the vessel.[1] Device compatibility and requisite sheath size often dictate the choice of core diameter.

Clinical needs such as tortuosity (increased flexibility), crossing a tight stenosis, as well as device compatibility and support (for example, 0.014-inch size for most atherectomy procedures, plus the need for column strength), should also be considered in the device selection process.

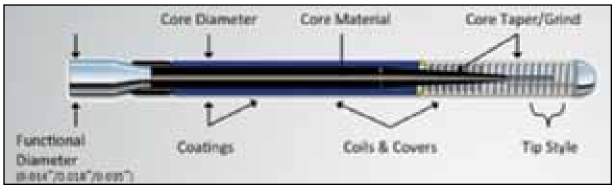

Figure 1. The basic building blocks of guidewires.

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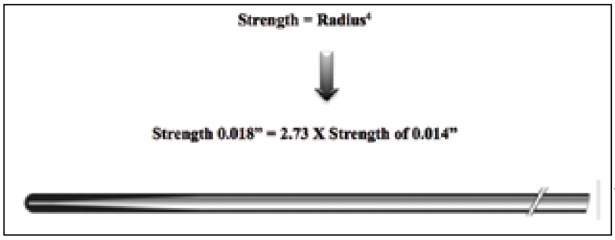

Figure 2. The strength of a wire is determined by its radius^4. Larger diameters improve torque, and smaller diameters have more flexibility.

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CORE MATERIAL

The core material of a guidewire affects flexibility, support, steering, and tracking. In general, stainless steel is easier to torque and is more rigid, providing better columnar support (Figure 3A and 3B). Nitinol is more flexible and kink resistant (Figure 3C and 3D). Developments such as high-tensile-strength stainless steel and combinations of stainless steel with nitinol have been utilized.[2] High-tensile-strength stainless steel provides more column strength and torquability than original stainless steel. The use of hybrid wires incorpo-

Image provided by Abbott Vascular.

Figure 3. Stainless steel guidewires are generally easier to torque and provide better column support. The first-generation designs were made of just stainless steel (A), but the second generation upgraded to high-tensile-strength stainless steel (B). Nitinol guidewires are more flexible and kink resistant. The first generation of nitinol wires (C) were then enhanced by the second generation design of stainless steel and nitinol (D).

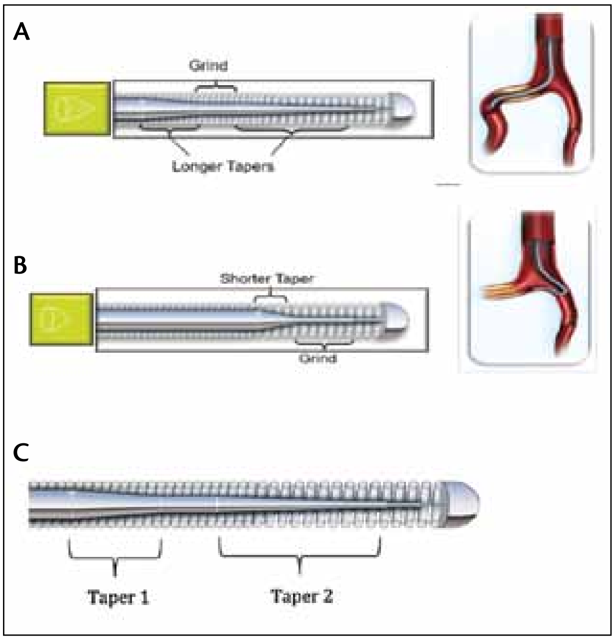

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Figure 4. Various core and taper grinds, including a gradual taper (A), a short taper (B), and multiple tapers (C).

rates high-tensile stainless steel shafts with nitinol tips to impart high torquability and columnar shaft strength with kink-resistance tips.

CORE TAPERS AND GRINDS

Broad, gradual, or long tapers offer acute vessel access and improved tracking (Figure 4A). Additionally, the wire follows itself well around bends. Devices with abrupt or short tapers create support in shorter distances and have a greater tendency to prolapse (Figure 4B). The core grind is a core with constant diameter (stated wire size), and the core tapers are areas where the core of the wire changes over a set distance. There may be several tapers in a wire (Figure 4C). Long, gradual tapers track well around bends, but do not provide as much support in short distances. Guidewire support charts are affected by core material, core diameter, and tapers (Figure 5).

TABLE 1. DESIGNING FOR PERFORMANCE CHARACTERISTICS

Feature →	Performance Characteristics →	Clinical Relevance
Core diameter, material	Torque transmission (steering)	Technique for advance/cross
Inner tip diameter	Tip stiffness	Lesion-crossing safety
Coatings and covers/sleeves	Lubricity	Lesion-crossing ability
Core diameter, taper length	Support	Device delivery/pushability
Material	Durability	Wire durability/technique
Tip design and material	Shaping and shape retention	Durability/push transmission
Core tapers and tip design	Penetration/trackability	Vessel access
Bare coils vs polymer covers	Tactile feedback	Safety and positioning
Core tip dimensions, polymer covers, and coatings	Lubricity vs safety	Penetrating power and lesion-crossing ability

Chart provided by Abbott Vascular.

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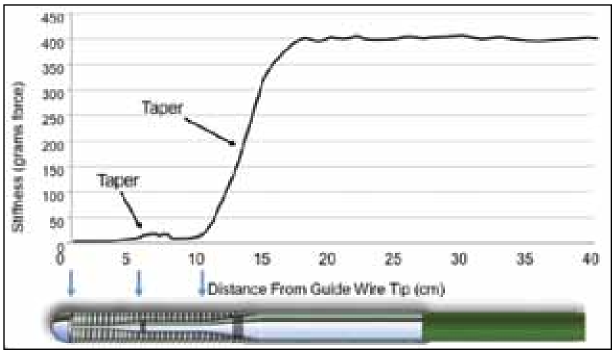

Figure 5. Guidewire support chart.

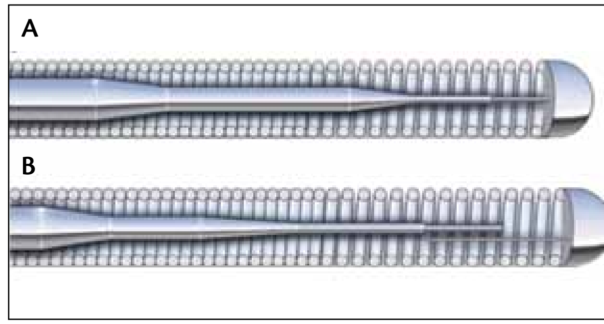

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Figure 6. Tip design options include core-to-tip (A) and shaping ribbon (B).

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Figure 7. Measurements of tip penetration (A). Area of guidewire tip (B). Tip stiffness/area of guidewire tip: 0.004 kg/(3.14 X 0.006 inch^2). Penetration power = 40 kg/inch^2.

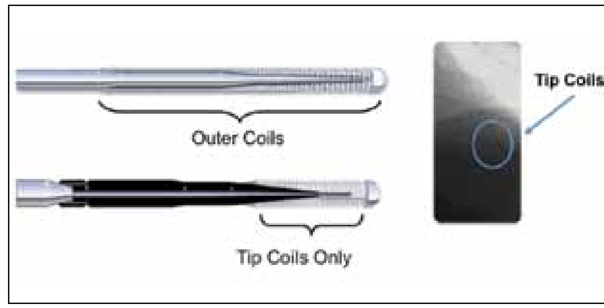

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Figure 8. Guidewire tip coils.

TIP DESIGN OPTIONS

Guidewire tip design affects steering and durability. A core that extends to the tip of the wire increases the transmission of force, is more durable and steerable, improves tactile feedback, and is ideal for use in peripheral vessels (Figure 6A). A core that does not extend to the tip (ie, the shaping ribbon design) is delicate, flexible, and soft (Figure 6B). This kind of tip is also easier to shape, can be easily prolapsed, and is less likely to inadvertently injure distal vessels. The tip penetration is a function of the tip stiffness and cross-sectional area of the tip.[1] Different levels of tip penetration provide the guidewire with more or less push force or "tip load" to cross challenging lesions (Figure 7).

Furthermore, guidewire tip coils affect support, tracking, shapeability, and radiopacity (Figure 8). Each of these attributes is positively affected by coils. The coils, however, also add to drag by increasing frictional elements.

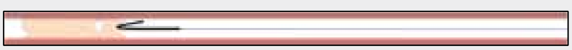
COVERS AND COATINGS

Guidewire covers are sleeves of polymer or plastic placed over the wire core to enhance lubricity (Figure 9). This results in less drag, enhanced lesion crossing, and smooth tracking in tortuous vessels. Hybrid wires with tip coils and covers are utilized to achieve a combination of desired effects.

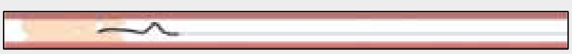
Hydrophobic coatings reduce friction and improve device trackability by repelling water to create a smooth, "wax-like"

TIPS FOR OPTIMIZING WIRE SUCCESS

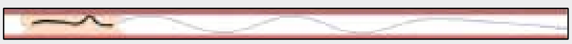
If the wire tip prolapses at the cap, use a wire with a higher tip gram load, or advance the support catheter near the tip.



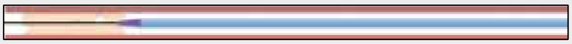
If the proximal segment of the tip buckles, use a wire with a higher tip gram load, a hydrophilic coating wire, or advance a support catheter near the occlusion.



If the tip enters the lesion and the wire fails to follow, use a wire with higher rail support, lower profile, or hydrophilic coating; or shorten the distance to the occlusion with a different approach (ie, antegrade vs contralateral).



If the wire crosses but the device fails to cross, change to a wire with higher rail support, advance the sheath closer to the occlusion, create a wiggle wire, or exchange for a lower-profile system.



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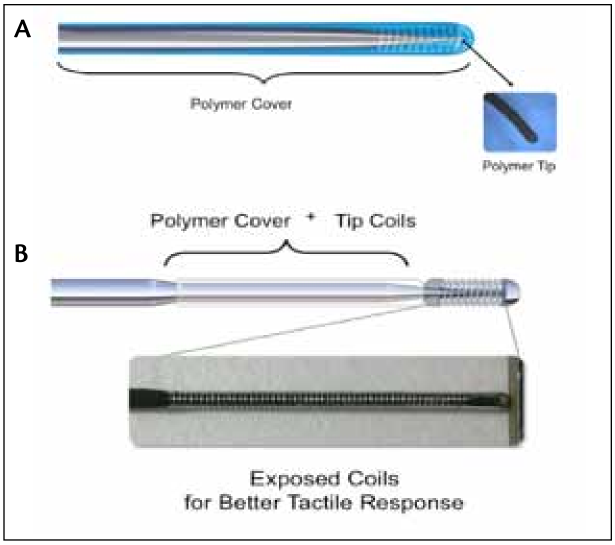

Figure 9. Guidewire covers. Polymer cover (A) and polymer cover and tip coils (B).

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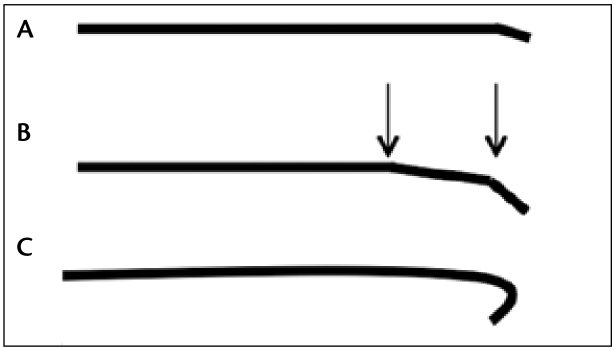

Figure 11. Penetrating the lesion entry point. Straight tips or small angles increase tip penetration (A). A secondary bend allows better navigation of a tortuous segment (B). When re-entering the true lumen from the subintima, J tips are ideal (C).

surface, with no water actuation required.[1] Hydrophilic coatings attract water to create a slippery, "gel-like" surface.[1] There is an inverse relationship between lubricity and tactile feedback.

GUIDEWIRE VISIBILITY

Visibility is directly related to wire diameter and the density of the materials used. Materials such as platinum and palladium are more radiopaque. The density of the material determines radiopacity. Visibility is an important component for wire visualization under fluoroscopy, as it confirms access in the target vessel and may aid in sizing the lesion for proper selection of device size (Figure 10).

WIRE LENGTH

Longer wires allow distal device delivery and catheter exchange without losing distal wire position. As a general

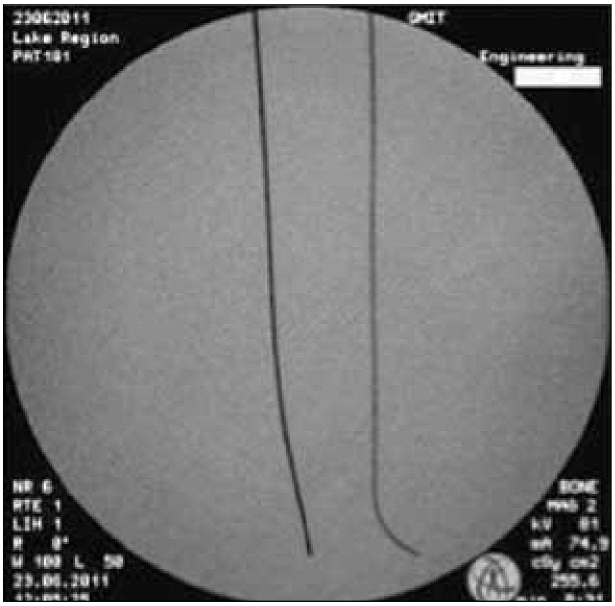

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Figure 10. The same core diameter wire with different materials. Victory guidewire (Boston Scientific Corporation, Natick, MA) on the left.

rule, however, there is a loss of torque response as the wire tip is farther from the torque site. Torque control is also diminished by tortuosity. Straight tips or small angles increase tip penetration (Figure 11). Adding a secondary bend may allow a better angle for navigation of tortuous segments. J tips are ideal for subintimal crossing and provide an atraumatic distal end, reducing the potential of perforating the vessel.[1]

CONCLUSION

Understanding wire characteristics is crucial to choosing the ideal wire or wires for a particular case. The ability to steer, cross, deliver therapy, avoid distal wire injury, straighten vessels, not induce kinks, and resist deformation or kinks is a function of wire design. Wire performance can also be affected by tortuosity, external support catheters, and proximity of the torque site to the treatment site. Advancements in guidewire design and a better understanding of how to use these wires results in improved procedural success. ■

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