Surgical Instruments: Manufacturing and Care

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Processing surgical instrumentation is an important daily function of veterinary practices. Understanding the properties of surgical instruments can help veterinary technicians and assistants see the value of correctly processing instruments to ensure their proper function and prolong their life. It is also important to identify the inherent key weaknesses of instrument design that can decrease quality, impair function, and increase the likelihood of retaining hazardous bioburden residue.

Instrument Manufacturing

Surgical instruments are precisely designed to serve important functions. During manufacturing, surgical instruments undergo forging, milling, tempering, polishing, passivation, and etching. With proper manufacturing and care, instruments can last for decades.

In the first step—forging—stainless steel is heated, and a rough stamp of the instrument's outline is created. There are forging mills throughout the world; some of the best-quality mills are in Germany. Conversely, in my experience, many mills in Pakistan produce such low-quality instruments that a repair company will not service them, so they must be discarded. If certain quality standards are not strictly maintained during manufacturing, instruments can be predisposed to premature breaking, rusting, and discoloration.

After forging, instruments are ground and milled. During milling, excess stainless steel from forging is removed to shape instruments, and special qualities (e.g., serrations, teeth, ratchets) are created. This is not a quick, one-step process: to produce good-quality instruments, milling is repeated multiple times to progressively shape instruments into their final form.

Once instruments have their final shape and characteristic details, tempering is performed to add strength to instruments. In this step, instruments are heated to as high as 1500°F (815.6°C) and then cooled under specific conditions to ensure that they develop the ideal hardness. If this step is performed incorrectly, an instrument can become brittle and break easily during normal use. Figure 1 shows an instrument that broke when the user tried, without much effort, to open it with the ratchets locked in place.

After tempering, polishing gives instruments a smooth finish, free of microscopic grooves that can retain organic debris. Instruments are given a shiny mirror finish or a duller satin finish. A mirror finish is highly polished and, therefore, resists spotting and discoloration best. However, during surgery, a mirror finish reflects light, which can strain the user's eyes. Therefore, a satin/dull finish may be preferred, but it does not resist spotting and discoloration as well as a mirror finish. High-quality instruments are available with either finish, which is chosen according to the surgeon's preference.

In the next step—passivation—the application of nitric acid (HNO₃) to instruments physically changes the outer layer of metal, removing iron atoms that are prone to oxidation (rusting) and depositing chromium oxide, which resists oxidation and protects instruments from corrosion. With normal use of instruments, the chromium oxide layer becomes more resistant to corrosion.

In the final step—etching—important identifying information (e.g., the manufacturer's name and/or location) is added to instruments. Generally, this is a chemical-based procedure that does not affect the integrity of an instrument's surface. Alternatively, identifying information may be physically stamped into low-quality instruments, possibly compromising an instrument by creating a depression in its surface and rendering it more prone to...
breakage or corrosion. Likewise, when practices engrave identifying information into their instruments, the grooves can collect organic material—increasing the bioburden—and compromise the integrity of the metal.¹

**Types of Metals**

Knowing about the types of metals from which instruments are made is important for knowing which instruments (1) are ideal for specific uses and (2) can be repaired or should be replaced.

Most surgical instruments are made from austenitic or martensitic stainless steel. Austenitic stainless steel (also known as 300 series stainless steel) is most often used to make retractors and suction tips. This stainless steel is unique because it is malleable. Conversely, martensitic stainless steel (also known as 400 series stainless steel) is much harder and, therefore, better suited for instruments that must maintain a precise cutting edge or tolerate more stress during use. Instruments such as scissors, needle holders, chisels, osteotomes, rongeurs, and hemostats are commonly made of martensitic stainless steel.¹

**Tungsten carbide** is an exceedingly strong, durable metal used to make the highest-quality surgical instruments, which are recognizable by their gold-colored handles. Commonly used only on the inner jaws of needle holders or the cutting edge of scissors, tungsten carbide strengthens these surfaces and retains a sharp edge (FIGURE 2 and FIGURE 3); the other parts of these instruments are usually made of stainless steel. Being able to determine which instruments have tungsten carbide is important because they can usually be repaired rather than replaced.¹ A proactive approach to instrument care and repair can save clinics money by avoiding or delaying instrument replacement.

For needle holders, tungsten carbide jaws are stronger than stainless-steel jaws and, therefore, last longer. When tungsten carbide jaws do wear out, they can be replaced without replacing the whole instrument, which saves money. When an all stainless-steel needle holder wears out, the whole instrument must be replaced.

Scissors with tungsten carbide blades are preferred because of their superior strength and ability to maintain a sharp edge compared with stainless steel. Before having tungsten carbide blades sharpened, confirm that they are dull so that a still usable blade is not sharpened away, shortening the life of the scissors.¹

**Intraoperative and Postoperative Care**

To lengthen their life, surgical instruments must receive routine care as they are used; lack of proper care cannot be compensated for later. One of the best care habits is to wipe blood and tissue off instruments during surgery.³ If possible, after the surgeon uses each instrument, wipe off blood or tissue with a sterile 4 × 4-cm gauze sponge moistened with sterile water.⁴ This not only prevents instruments from sticking during surgery but also makes cleaning easier later because there is not as much dried blood and tissue to remove. Allowing blood to dry on instruments can damage the protective chromium oxide layer, resulting in staining, pitting, and corrosion.⁵ Saline can also damage the chromium oxide layer; therefore, saline should never be used to wipe or soak instruments.¹ To wet instruments, it is best to use deionized or distilled water to avoid mineralized deposits or stains due to tap water.¹⁵

Instrument cleaning should begin immediately after a surgical procedure is complete. Review either your state’s workplace safety and health regulations or, if your state does not have them, the Occupational Safety and Health Administration regulations on personal protective equipment. At a minimum, wear gloves until instruments have been decontaminated. Begin by rinsing heavily soiled instruments under lukewarm or cool water (i.e., <110°F [43°C]) because hot water causes coagulation of proteins in blood, making it more difficult to remove.⁶ Once some of the gross organic debris has been rinsed off, begin cleaning instruments by hand using a soft brush and a detergent approved for this purpose. Neutral or mildly alkaline detergents are preferred, so detergents with a pH of 6.0 to 8.5 are best, but those with a mildly alkaline pH of 9.2 to 11 are also acceptable.¹⁵ Manual cleaning (by hand with a brush) in water alone is inadequate, so a detergent should also be used.¹ Washing instruments in water without a detergent can not only leave a large amount of organic debris but also affix debris to instruments.⁷

It is important to use a detergent specifically made to remove biologic proteins from stainless steel. Common household cleaners, detergents, and cleansers must never be used because they can damage instrument surfaces and promote corrosion. Enzymatic products are especially useful because the enzymes break down organic molecules such as those in protein, fat, and starch. No solution alone will clean instruments, so it is necessary to physically scrub each instrument thoroughly with a soft-bristled brush. To protect yourself and those around you from aerosolizing bacteria,
always totally immerse instruments and brush them below the water level. Once manual cleaning is complete, rinse instruments thoroughly with fresh water.

If instruments cannot be cleaned immediately, help preserve them by preventing blood and tissue from drying on them. Effective methods include applying an enzymatic spray to instruments to break down organic debris, placing instruments in a special soaking solution, and covering instruments with a wet towel to keep them moist until they can be properly cleaned. Bioburden left on instruments can cause cracking, staining, and stiffness.

Once manual cleaning is complete, it is recommended to use an ultrasonic cleaning machine, this is called mechanical cleaning. Ultrasonic cleaning is 16 times more effective than manual cleaning, so it is important to perform every time instruments are used. However, ultrasonic cleaning alone is not adequate (coagulated proteins left on instruments will inhibit ultrasonic cleaning action), so it must be preceded by manual cleaning. Ultrasonic cleaners work by a process called cavitation to lift small bits of debris from hard-to-reach places (e.g., creases, crevices) that may be missed by cleaning with a brush. To avoid aerosolizing potentially harmful microorganisms, ultrasonic machines should always be operated with their lids closed.

For effective cleaning, instruments should be in their open position when they are loaded into the machine. To avoid damaging instruments due to electrolytic corrosion, stainless-steel instruments should not be processed in the same ultrasonic cycle as other metals, such as aluminum or brass. Because the water in the machine may be filled with debris after use, rinse the instruments after the ultrasonic cycle. Figure 4 provides a tip for ensuring that a machine is working properly.

When all gross organic debris has been removed from instruments, microorganisms and their spores must be removed or killed through decontamination. The ideal disinfectant (1) is effective against bacteria, viruses, fungi, and prions; (2) is fast acting; and (3) does not bind organic material to the surface of instruments. The disinfectant should be designed for safe use on instruments; for example, iodine or chlorine (bleach) compounds should not be used because they can cause corrosion. After decontaminating instruments for the appropriate time according to the manufacturer’s instructions, rinse them off again. This final rinse is the most important time to use distilled or deionized water instead of tap water, which can leave deposits on instruments.

To prolong their life, instruments should be lubricated (“milked”) after decontamination and rinsing. Lubricating and conditioning products known as instrument milk are available. These water-soluble solutions are removed with each cleaning, so it is important to relubricate instruments after every use. In addition to lubricating instrument hinges, instrument milk forms a protective layer to help prevent corrosion, rusting, and dulling of sharp edges. Instrument milk is often designed to prevent interference with steam and ethylene oxide sterilization methods; therefore, excess milk can be allowed to drain off, but the remaining milk does not need to be wiped or rinsed off before steam or ethylene oxide sterilization.

Instruments should be allowed to air dry; towel drying may leave lint or other particles that should not be introduced into the surgical field.

Inspection

After instruments have been cleaned and lubricated, they should be inspected to ensure that (1) all bioburden has been removed before packaging and sterilization and (2) the instruments are working properly to allow efficient use by the surgeon. Basic ringed instruments, such as hemostats and needle holders, have a few common parts. Being able to identify the tips, jaws, box lock, shanks, ratchets, and rings can help technicians describe instrument problems to the veterinarian or repair personnel (Figure 2 and Figure 5).

Begin inspection at the tips of instruments. Ensure there are no cracks or broken jaws or tips on needle holders (Figure 6 and Figure 7). Cracked needle holders are dangerous because pieces of their jaws can break off and remain inside a patient. Debris can hide in serrated jaws and box locks, so these parts should be inspected carefully. Examine the surfaces of the jaws and open the box lock as wide as possible to check for blood and tissue.

Because cracks are often found in box locks, inspect them closely and open and
close instruments several times to detect abnormal function. Hold instruments as the surgeon would and use the rings to open and close them, checking to ensure that the ratchets latch securely with each click and are easily undone using one hand. On initial closure, ensure that interlocking pieces at the tip (e.g., rat-teeth instruments) occlude correctly. When closing instruments, you should be able to see and feel whether their parts align correctly.

For scissors, the above inspection techniques can be used. Instead of having a box lock, scissors have a screw hinge (FIGURE 3) that should be inspected for looseness, cracks, or bioburden. Hold scissors as the surgeon would, opening and closing them to ensure that they glide smoothly and the cutting edges are closely opposed. It is a good idea to have a small toolkit for tightening screws—a simple fix that you can do on your own.

Special scissors-testing material can help assess cutting ability and determine whether sharpening is necessary. Testing materials for different scissors sizes can mimic body tissues. To avoid dulling the cutting edge, do not test scissors using gauze or other materials, such as paper products. When using testing material, start cutting it close to the screw hinge. Scissors should be able to cut cleanly and easily along the entire length of the blades.

To inspect instruments such as a thumb or tissue forceps, pay special attention to the distal tip. Close them to ensure that they move freely without catching or sticking. Look closely to ensure that interlocking parts meet up correctly and that the teeth are not bent. Look inside the grooves where the teeth meet because debris often accumulates there (FIGURE 8). Check the joint at the proximal end of the forceps for debris.

### Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
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<tbody>
<tr>
<td>Austenitic</td>
<td>Stainless steel that cannot be heat-hardened and is nonmagnetic; it resists corrosion better than martensitic steel; also known as 300 series stainless steel</td>
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<tr>
<td>Bioburden</td>
<td>Microorganisms and tissue that remain on and contaminate an instrument</td>
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<tr>
<td>Box lock</td>
<td>Place where the two pieces of an instrument (e.g., needle holder, hemostat) meet and pivot</td>
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<tr>
<td>Cavitation</td>
<td>A process that ultrasonic cleaners use to produce bubbles that implode to remove debris from instruments</td>
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<tr>
<td>Coagulate</td>
<td>To form a blood clot</td>
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<tr>
<td>Decontaminate</td>
<td>To remove a contaminating substance or pathogen using a physical or chemical process</td>
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<tr>
<td>Deionized water</td>
<td>Water in which ions with an electrical charge have been removed</td>
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<tr>
<td>Disinfect</td>
<td>To kill all or almost all microorganisms (except spores) that can cause disease; disinfectant usually refers to chemicals that are used on inanimate objects</td>
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<tr>
<td>Distilled water</td>
<td>Water that has a pH of 7.0 and no minerals; created by heating water to the boiling point, vaporizing it, cooling it, and condensing it into a liquid</td>
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<td>Electrolytic corrosion</td>
<td>This can happen during ultrasonic cleaning if one type of metal is removed from an instrument and makes contact with a different metal</td>
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<td>Gross debris</td>
<td>Organic debris (e.g., blood, tissue) that is visible to the naked eye</td>
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<tr>
<td>Malleability</td>
<td>A characteristic of some metals that allows them to be bent and formed into different shapes</td>
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<tr>
<td>Martensitic</td>
<td>Stainless steel that is magnetic and can be heat-hardened; it does not resist corrosion as well as austenitic stainless steel; also called 400 series stainless steel</td>
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<tr>
<td>Passivation</td>
<td>During instrument manufacturing, application of an invisible layer of chromium oxide to help resist corrosion</td>
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<tr>
<td>Pathogenic</td>
<td>Ability of a microorganism to cause disease</td>
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<tr>
<td>pH</td>
<td>A measure of alkalinity or acidity; on a scale of 0 to 14, 7 is neutral, 0 to &lt;7 is acidic, and &gt;7 to 14 is alkaline</td>
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<td>Prion</td>
<td>A disease-causing protein that is not viral, bacterial, or fungal; usually related to brain diseases such as scrapie or mad cow disease, prions can be difficult to destroy</td>
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<tr>
<td>Ratchet</td>
<td>The part of an instrument (e.g., hemostat) that locks it shut</td>
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<tr>
<td>Sterilization</td>
<td>A physical or chemical process that destroys all microorganisms and pathogens (i.e., bacteria, viruses, fungi, and spores) that may cause disease</td>
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<tr>
<td>Tungsten carbide</td>
<td>A harder, more durable metal than stainless steel; instruments made of tungsten carbide can be identified by their gold handles</td>
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All surgical instruments also need to be inspected for pitting, corrosion, and rust. A simple test can help differentiate between these problems and stains: a pencil eraser should easily remove stains on instruments; commercial pastes, powders, and liquids are also available for stain removal. Pitting, corrosion, and rust indicate a compromised instrument surface and can lead to further breakdown; therefore, affected instruments should not be used.

One of the last steps of proper instrument care is to ensure that delicate instruments are protected during packaging. In large instrument sets, it is important to place heavier instruments on the bottom and smaller, more delicate instruments on the top. Because packaged instruments can shift during transport through a hospital, it may be wise to invest in tip protectors or foam sleeves for instruments such as delicate scissors, fine-tipped needle holders, or tiny skin hooks. These products also help prevent staff members from being injured by a sharp instrument when reaching into a set. Plastic tip protectors are available in various styles and sizes, so they can be tailored to a hospital’s instruments, sterilization method, or other needs (FIGURE 9).

**Conclusion**
Proper instrument care is vital to high-quality patient care and to saving money in a hospital’s surgery program. Keeping instruments working properly and out of the “repair shop” can help keep a surgery program functioning smoothly. With appropriate care and maintenance, surgical instruments can serve their intended purposes well for many years.

**References**
1. Water-soluble instrument lubricants are removed
   a. as soon as blood touches them.
   b. by a final rinse before sterilization.
   c. each time instruments are washed.
   d. with a specially designed solution.

2. The proper order for instrument processing is
   a. saline soak, wash, rinse, ultrasonic cleaning, rinse, lubricate, air dry.
   b. wash, rinse, ultrasonic cleaning, rinse, decontaminate, rinse, lubricate, air dry.
   c. wash, rinse, ultrasonic cleaning, rinse, disinfect, rinse, lubricate, towel dry.
   d. wash, rinse, ultrasonic cleaning, rinse, lubricate, rinse, air dry.

3. The best way to care for instruments in the surgical suite is to
   a. wipe them with a moist, 4 × 4–cm gauze sponge after each use.
   b. soak them in sterile saline.
   c. cover them with a moist towel.
   d. let blood dry on them to build a protective chromium oxide layer.

4. Martensitic stainless steel is preferred for producing
   a. malleable instruments, such as retractors and suction devices.
   b. instruments that need to maintain a sharp edge.
   c. instruments that must tolerate a lot of stress.
   d. b and c

5. For cleaning instruments, water should be
   a. ice cold to halt bacterial growth.
   b. lukewarm or cool to prevent coagulation of proteins.
   c. hot to begin killing germs.
   d. none of the above

6. Which process creates a protective chromium oxide layer?
   a. forging
   b. milling
   c. tempering
   d. passivation

7. Ultrasonic cleaning is ____ times more effective than manual cleaning.
   a. 6
   b. 16
   c. 26
   d. 36

8. Tungsten carbide instruments
   a. contain no stainless steel.
   b. are usually chisels, osteotomes, and rongeurs.
   c. can have their jaws or blades replaced.
   d. that show wear must be discarded because they cannot be repaired.

9. When an instrument set is packed,
   a. heavier instruments should be placed at the bottom and more delicate instruments on top.
   b. small, delicate instruments should be placed beneath heavier ones to prevent sliding and damage.
   c. using tip protectors is a waste of money because staff members should be careful not to cut themselves.
   d. damage to instruments should not be a concern because stainless steel is strong.

10. Inspecting instruments is important for
    a. identifying dangerous pieces that may break off inside a patient.
    b. finding remaining bioburden that could cause infection.
    c. assisting the surgeon by removing dysfunctional instruments.
    d. all of the above