

Colposcopes: A Critical Review

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A multidimensional professional team consisting of a practicing colposcopist, a mechanical engineer, and a medical photographer independently critically evaluated the features of selected colposcopes.

Qualitative observations and quantitative measurements were performed on 13 colposcopes representing eight manufacturers and distributors. Optical characteristics, ocular system operation, mobility and stability, relative ease of use, component characteristics, space for instrumentation, and visual illumination, unifor-

As more eager novice colposcopists are being trained to perform colposcopy,¹ the initial inquiry about colposcopes, necessary equipment, and purchase selection becomes a critical issue. Financial constraints, present and future applications, office space limitations, and educational objectives should be addressed before colposcope purchase. Most important, the eventual choice of a colposcope should ultimately provide ease of use and reflect practice style and requirements.

Colposcope reviews are limited and in the past have usually provided only component data, specifications, accessory options, and estimated prices.^{2,3} A contemporary, comprehensive critical review of colposcopes has been previously unavailable to clinicians. Eight of nine major US colposcope manufacturers and distributors responded to our request in October 1990 to evaluate their colposcopes. Each corporation was allowed to submit two colposcopes of their choice for critical evaluation.

A multidimensional professional team consisting of a practicing colposcopist, a mechanical engineer, and a medical photographer independently evaluated the selected colposcopes and features. The colposcopist examined the colposcopes from a clinician's perspective for overall function, utility, and perceived quality. The mechanical engineer evaluated structural and mechanical

mity, and color were comparatively assessed.

The specific colposcope information provided may benefit practicing physicians or novice colposcopists who are contemplating purchasing a colposcope. The presented framework of critical feature evaluation may also facilitate the informed selection of other colposcopes not included in this selective, critical, comprehensive review.

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features as well as the construction materials used. The medical photographer evaluated the optical characteristics of the respective colposcopes and provided the necessary expertise for qualitative and quantitative photographic documentation of the optical systems.

The Colposcope

Colposcopy is a clinical procedure for examining the epithelium of the uterine cervix and surrounding anogenital area. The colposcope is simply a microscope-like instrument with a powerful light source that is used to magnify and illuminate surface epithelium and the underlying vasculature within the connective tissue stroma. Characteristic tissue images, composed of epithelial cell morphology and vascular patterns, enable the clinical recognition of pathology. The procedure is enhanced by the use of chemical solutions (acetic acid and Lugol's iodine) applied to the epithelium as contrasting agents to assist in differentiating normal from abnormal tissue.

The colposcope (Figure 1) is used chiefly to evaluate cytologic abnormalities detected by Papanicolaou smears. The colposcope also facilitates the evaluation of viral-induced lesions of the genital region. In addition, the colposcope allows examination of the male genitalia, referred to by some as androscopy. Many colposcopes may be used as an operating microscope for selected otolaryngoscopic examinations and outpatient surgical procedures when magnification is required.

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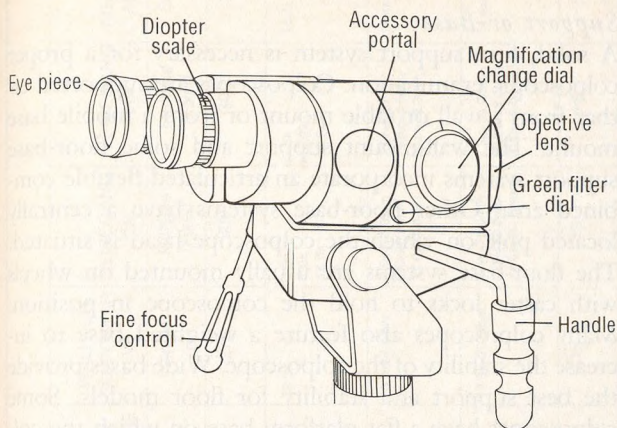


Figure 1. Colposcope components.

Components

A basic colposcope configuration consists of four distinct ocular devices (Figure 2). The objective lens, located nearest to the subject, is a convex or image-converging type of lens. The objective lens determines the focal length (distance between the subject and the colposcope). The focal length also approximates the working distance (the area between the subject and the colposcope) to allow sufficient space for instrumentation. Many colposcopes have two separate objective lenses that synergistically produce a stereoscopic or three-dimensional visual image. Some colposcopes allow a choice of optional objective lenses.

Next, located between the colposcopist and the objective lens(es) is the magnification adjustment complex. Colposcopes have either a single fixed magnification, a zoom or continuum magnification system, or multiple, distinct, interchangeable magnifications. The spectrum of magnification available is variable for different colposcopes but is generally between two and twenty-five times magnification. The higher magnifications ($15\times$ and above) allow sufficient pathology resolution to for-

mulate a clinical colposcopic impression. Lower magnification ($2\times$ to $5\times$) allows a larger field (diameter) of view and depth of field (depth of tissue in focus) to permit necessary tissue scanning, particularly of the external genitalia. Treatment of disease is best accomplished when visualized at a lower magnification. Consequently, fixed single magnification colposcopes are less versatile.

The binocular tubes and lenses are sequentially positioned next, closer to the colposcopist. The binocular system contains an objective lens and a prism system that inverts the subject image to a right-side-up position.⁴ The system also allows the colposcopist to make individual interpupillary distance adjustments.

The eyepieces, or oculars, complete the colposcopic lens system. The eyepieces provide further magnification of the subject image. Some colposcopes have interchangeable eyepieces that permit a change in subsequent magnification. Most eyepieces incorporate a diopter adjustment that permits independent focus alterations between the two individual eyepieces. This feature enables colposcopists who wear glasses to adjust the colposcope to fit their ocular prescription and thus be able to perform colposcopy without their glasses. The diopter adjustment also allows for focusing variability between different colposcopists within the same clinic.

Features and Options

The review included many different types of colposcopes with diverse features: wall-mounted and mobile base-mounted; single, zoom, and multiple fixed magnification; various illumination systems; and documentation and education-enhancing accessory equipment. As the potential features and number of distinct options increase, so does the overall price for the colposcope. However, price does not always correlate with the optical characteristics of the colposcope.

Magnification

Many magnification options exist for colposcopes. There are three basic types: a single fixed magnification, a zoom magnification, and a multiple fixed magnification. Image magnification is changed with a magnification adjustment dial or, in other scopes, by substituting different eyepiece oculars. A colposcope with a magnification range between $2\times$ and $16\times$ is ideal for clinical use. As total magnification increases, the visual field diameter and the depth of the visual field inversely decrease. Total surface illumination also decreases as magnification is increased. Therefore, most colposcopes with magnification above $20\times$ usually do not have a sufficient light source to provide adequate illumination of the tissues.

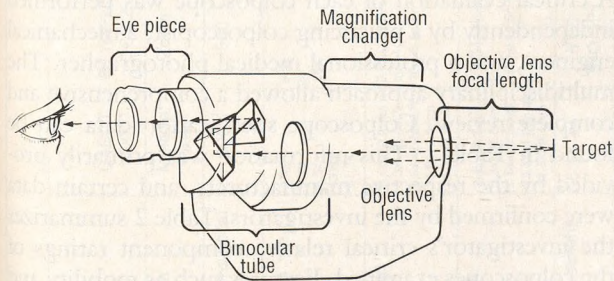


Figure 2. The colposcope optical system includes the eyepiece, binocular tube, magnification complex, and the objective lens(es).

Light Source

The second necessary component of a colposcope is illumination. Light sources or bulbs should be readily accessible for rapid changing when required. The bulbs are halogen, xenon, tungsten, or incandescent. Very often the light source is not located in the head of the colposcope. Light in this case is transmitted by a fiberoptic cable and is perceived as being cooler.

The fiberoptic cable may be the weakest component of the illumination system. If not handled cautiously, fibers within the cable can be broken, which will result in decreased lighting and nonuniform light patterns. Some colposcopes have fiberoptic cables that are externally positioned. These cables are then placed between the colposcopist and the patient and are at risk of being damaged. Halogen bulbs provide a pure white light source, which is favored by many colposcopists. Some light sources require a small fan to dissipate generated heat and preserve the length of bulb service. The illumination intensity control switch is a rheostat that provides an optional spectrum of illumination, but may also be a fixed three-step selection switch.

Focus

Usually, the colposcope is focused by two methods. Coarse focus is initiated by moving the colposcopic head to approximately the objective lens focal-length distance from the subject. If the colposcope is focused at highest magnification initially, subsequent lower magnification will be in par focus. Many colposcopists, however, choose to focus initially at low power and readjust focus as magnification is increased. A fine-focus handle is included on many colposcopes. With this fine-focus system, the colposcope base or arm remains stationary, and only the colposcope head is moved toward or away from the patient. The diopter adjustments located on each eyepiece ocular allows individual focus for each eye.

Green Filter

Most colposcopes, except some colposcopes that project green light, have green filters. The green filter absorbs red light, and the transmitted visual image of the vasculature is perceived as black. The green filter is most useful when examining vascular patterns. Usually the green filter is activated by a dial located on the colposcopic head. Some colposcopes have a slide mechanism for the green filter. The filter should be encased within the body of the colposcope so that dust does not accumulate on the green filter. Use of the green filter also diminishes the intensity of observed illumination.

Support or Base

A solid, firm support system is necessary for a proper colposcopic examination. Colposcopes are supported either from a wall or table mount or from a mobile base mount. The wall-mount support and some floor-base support systems incorporate an articulated flexible combined arm. Other floor-base systems have a centrally located pole on which the colposcope head is situated. The floor-base systems are usually mounted on wheels with caster locks to hold the colposcope in position. Many colposcopes also feature a weighted base to increase the stability of the colposcope. Wide bases provide the best support and stability for floor models. Some colposcopes have a flat platform base on which the colposcopist's feet are positioned to facilitate colposcopic stability. A wall-mounted colposcope limits colposcopic examinations to the room in which it is placed. The floor-base models on wheels generally have good mobility and can be maneuvered into adjoining examination rooms.

Accessory Portals or Video Adapters

Many colposcopes have ocular accessory portals or video adapters to allow the addition of other components. Accessory portals can be used for teaching head scopes, 35-mm cameras, Polaroid cameras, and video cameras. The portals facilitate education and documentation. Office-based colposcopy, however, does not require these accessory portals.

Laser Capability

Many colposcopes are equipped to add a laser unit. The laser micromanipulator can be positioned differently depending on the colposcope type. Laser-adaptable colposcopes should have multiple magnification systems and stable colposcopic head platforms.

How the Colposcopes Were Evaluated

A critical evaluation of each colposcope was performed independently by a practicing colposcopist, a mechanical engineer, and a professional medical photographer. The multidisciplinary approach allowed a comprehensive and complete review. Colposcope specification data can be found in Table 1. This information was primarily provided by the respective manufacturers, and certain data were confirmed by the investigators. Table 2 summarizes the investigator's critical relative component ratings of the colposcopes examined. Features such as mobility and stability, stationary characteristics, ocular system operation, the relative ease of use, the working area or space to allow instrumentation, optical characteristics, and overall

Table 1. Colposcope Specifications

Variables	CABOT 6000	OLYMPUS OCS-2	JEDMED SOM 2/5	JEDMED KP 6/3	FRIGI-TRONICS ZM310	FRIGI-TRONICS 280	ZEISS ZMS-501-11	ZEISS ZMS-506-11	WALLACH ZOOMSCOPE	WALLACH COLPOSTAR V6	LEISEGANG IDL	LEISEGANG 3BD	MEDGYN AL-102
Magnification System	Multiple Fixed	Zoom	Multiple Fixed	Multiple Fixed	Zoom	Single	Multiple Fixed	Multiple Fixed	Zoom	Single	Multiple Fixed	Multiple Fixed	Single
Objective Lens Focal Length (mm)	300	300	300	300	310	280	300	300	300	275	300	300	275
Magnification Options (x)	3.4x 5.3x 8.5x 13.6x 21.3x	5.4x to 16x	2.7x 4.2x 6.6x 10.6x	4.2x 6.6x 10.6x	4.6x to 17.4x	16.0x	6.2x 10.3x 16.4x	3.4x 5.0x 8.4x 13.4x 21.0x	3.5x to 15.0x	13.5x	3.5x 7.0x 14.0x	7.5x 15.0x 30.0x	14.4x
Depth of Field	3.4x=10.2mm 5.3x=4.5mm 8.5x=2.2mm 13.6x=1.2mm 21.3x=0.9mm	5.4x=10.5mm to 16x=1.3mm	2.7x=28.0mm 4.2x=7.0mm 6.6x=4.0mm 10.6x=n/a 16.6x=n/a	4.2x=7mm 6.6x=4mm 10.6x=n/a	4.6x=20.6mm to 17.4x=2.4mm	16.0x=4mm	6.2x=16.1mm 10.3x=8.1mm 16.4x=3.8mm	3.4x=48.0mm 5.0x=20.9mm 8.4x=10.4mm 13.4x=4.9mm 21.0x=3.1mm	13.0x=5.0mm	13.5x=4.0mm	3.5x=16.0mm 7.0x=8.0mm 14.0x=4.0mm	7.5x=8.0mm 15.0x=4.0mm 30.0x=2.0mm	14.4x=4.5mm
Field of View	3.4x=58.5mm 5.3x=37.5mm 8.5x=27.5mm 13.6x=14.6mm 21.3x=9.4mm	5.4x=46.0mm to 16.0x=15.5mm	2.7x=66.0mm 4.2x=41.0mm 6.6x=26.4mm 10.6x=16.5mm 16.6x=10.6mm	4.2x=41.9mm 6.6x=26.4mm 10.6x=16.5mm	4.6x=49.2mm to 17.4x=11.5mm	16.0x=18.2mm	6.2x=30.0mm 10.3x=18.0mm 16.4x=11.0mm	3.4x=59.0mm 5.0x=40.0mm 8.4x=24.0mm 13.4x=15.0mm 21.0x=9.5mm	3.5x=53.2mm to 15.0x=12.4mm	13.5x=20.0mm	3.5x=78.0mm 7.0x=39.0mm 14.0x=20.0mm	7.5x=36.0mm 15.0x=18.0mm 30.0x=9.0mm	14.4x=12.5mm
Diopter Adjustment Scale	-6 --> +4	YES (NO CPT)	±5	±5	YES NO SCALE	YES NO SCALE	±3	±8	YES NO SCALE	±5	±6	±6	±5
Reticles	NO	YES	NO	NO	NO	NO	YES	NO	NO	NO	YES	YES	YES
Interchangeable Eyepieces	YES	NO	YES	YES	YES	YES	YES	YES	YES	NO	NO	NO	YES
Fine Focus Position (R/L)	L	L	BOTH	R	L	L	L	BOTH	BOTH	L	L	L	L
Illumination Source	Tungsten	Halogen	Xenon	Halogen	Halogen	Incan- descent	Halogen	Halogen	Halogen	Tungsten	Halogen	Halogen	Incan- descent
Fiberoptic	NO	YES	NO	YES	YES	NO	YES	YES	YES	NO	NO	NO	NO
Illumination Intensity Control	3-Step	Variable	Variable	Variable	Variable	Variable	Variable	Variable	Variable	3-Step	Variable	Variable	3-Step
Support	CP ¹	FA ²	WA ³	CP ¹	CP ¹	CP ¹	FA ²	FA ²	FA ²	CP ¹	CP ¹	FA ²	CP ¹
Accessory Ports	YES	YES	YES	YES	NO	YES	YES	YES	NO	NO	NO	YES	NO
Beam Splitter	Included	Included	\$1,195	\$1,195	NO	Included	\$1,800	\$1,800	NO	NO	NO	NO	NO
Teaching Head	\$1,626	NO	\$1,995	\$1,995	NO	\$1,675	\$4,000- \$8,000	\$4,000- \$8,000	NO	NO	NO	\$1,395	NO
Laser Adaptable	YES	YES	YES	YES	YES	YES	YES	YES	NO	NO	YES	YES	NO
Warranty (Parts/Labor)	3 yrs.	1 yr.	10 yrs.	10 yrs.	5 yrs.	5 yrs.	1 yr.	1 yr.	1 yr.	1 yr.	1/5 yrs.	1/5 yrs.	1 yr.
Factory/Repair	Japan/PA	Japan/NY	Germany/ MO	Germany/ MO	Japan/CT	Japan/CT	Germany/ On-site	Germany/ On-site	/CT	/CT	Germany/FL	Germany/FL	Japan/IL
Price	\$8,295	\$4,800	\$7,599	\$4,995	\$3,985	\$3,795	\$8,900	\$7,200	\$4,965	\$3,195	\$5,845	\$13,590	\$2,550

¹ Center Pole; ² Flexible Arm; ³ Wall-mounted

Table 2. Colposcope Evaluation

Variables	CABOT 6000	OLYMPUS OCS-2	JEDMED SOM 2/5	JEDMED KP 6/3	FRIGI-TRONICS ZM310	FRIGI-TRONICS 280	ZEISS ZMS-501-11	ZEISS ZMS-506-11	WALLACH ZOOMSCOPE	WALLACH COLPOSTAR V6	LEISEGANG IDL	LEISEGANG 3BD	MEDGYN AL-102
Mobility	●	●	● ¹	●	●	●	●	●	●	●	●	●	●
Stability	●	●	● ¹	●	●	●	●	●	●	●	●	●	●
Weighted Base	NO	NO	NA	●	NO	NO	●	●	NO	NO	NO	●	NO
Holds Position	●	●	●	●	●	●	●	●	●	●	●	●	●
Height Adjustment Fine	●	● ²	● ²	●	●	●	● ²	● ²	● ²	●	●	●	●
Height Adjustment Gross	●	●	●	●	●	●	●	●	●	●	●	●	●
Holds Focus	●	●	●	●	●	●	●	●	●	●	●	●	●
Location of Dials	●	●	●	●	●	●	●	●	●	●	●	●	●
Dial Operation	●	●	●	●	●	●	●	●	●	●	●	●	●
Magnification Dial	●	●	●	● ³	● ⁴	● ⁵	●	● ⁴	● ⁴	NA	● ³	● ³	● ⁵
Green Filter	●	●	●	●	●	●	●	●	●	●	●	●	●
Fine Focus	●	●	●	●	●	●	NONE	●	●	●	●	●	●
Power	●	●	●	●	●	●	●	●	●	●	●	●	●
Light Source (Bulbs)	●	●	●	●	●	●	●	●	●	●	●	●	●
Visual Coverage	NOT GOOD < 6x	GOOD	BAD AT LOW END	GOOD	GOOD	GOOD	NOT GOOD	JUST BARELY	LOW POWER BAD	GOOD	GOOD	GOOD	GOOD
Visual Uniformity	UNEVEN	UNEVEN	EVEN	EVEN	EVEN	EVEN	UNEVEN	UNEVEN	EVEN	EVEN	EVEN	EVEN	EVEN
Visual Color	NEUTRAL	NEUTRAL	NEUTRAL	WARM	WARM	NEUTRAL	WARM	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL
Visual Illumination	●	●	●	●	●	●	●	●	●	●	●	●	●
Clarity	●	●	●	●	●	●	●	●	●	●	●	●	●
Optics	●	●	●	●	●	●	●	●	●	●	●	●	●
Materials	●	●	●	●	●	●	●	●	●	●	●	●	●
Instrumentation Freedom	●	●	●	●	●	●	● ^{6/7}	●	●	●	●	●	●
Operator Ease of Use	●	●	●	●	●	●	●	●	●	●	●	●	●
Recommendation	●	●	●	●	●	●	●	●	●	●	●	●	●

¹ Wall-mounted
² Flexible arm
³ Large
⁴ Small
⁵ None
⁶ With camera
⁷ Without camera

Superior ● Excellent ● Very Good ● Good ● Average ● Below Average ● Fair ● Poor ● Unacceptable

← RATING SCALE →

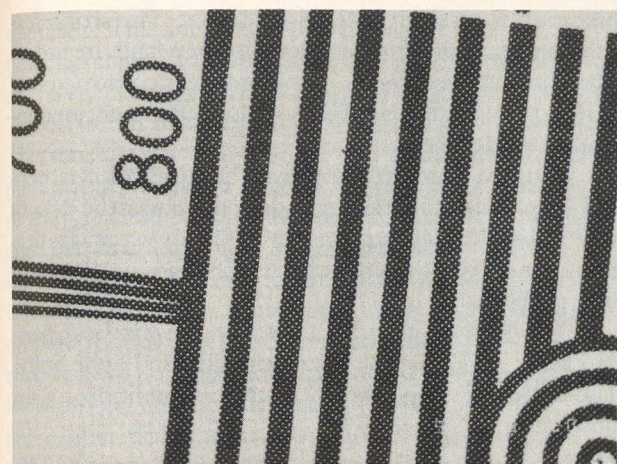


Figure 3. The photographic grid or register used to compare colposcope optical characteristics.

ratings were included. Of note, both tables summarize the features of colposcopes representing various price ranges. In general, colposcopes were critically rated without knowledge of and irrespective of actual listed suggested price. The actual purchase prices may vary between locations and sales representatives.

While the qualitative evaluation was somewhat subjective, a quantitative evaluation was also performed. Quantitative evaluations were permitted with photographic documentation. Each colposcope supplied with 35-mm capabilities was evaluated independently. All colposcopes were examined and visually appraised on the color, illumination uniformity, and coverage of illumination (eg, the surface illuminated area compared with the surface area observed). Figure 3 illustrates the ability of the optics to demonstrate fine magnified details.

The visual color of illumination was judged by illuminating an 18% gray card and a Macbeth color checker. Visual color was judged to be neutral, cool (bluish), or warm (reddish). Visual illumination uniformity and coverage of illumination were evaluated by observing the pattern and size of the light source relative to the area observed. Visual observations were made at all possible magnifications.

The Colposcopes Reviewed

Each colposcope listed was reviewed independently by members of the evaluating team. Both positive and negative features and comments about each colposcope are included here.

Cabot 6000

The Cabot 6000 colposcope (Cabot Medical, Langehorn, Pa) is the top-of-the-line model for this manufacturer. The versatility of this scope is demonstrated by its range of magnifications: 3.4 \times , 5.3 \times , 8.5 \times , 13.6 \times , and 21.3 \times . (The 8.5 \times magnification is represented twice on the magnification changer dial.) When the accessory portals are fully occupied, the magnification changer is somewhat difficult to reach. The scope contains a three-step light-intensity source. Illumination at 21.3 \times magnification is insufficient for clinical use. The support stand is equipped with a hydraulic height-adjustment system to prevent a possible sudden drop of the instrument, which could damage the colposcopic head. This protection system is so effective that it is actually difficult to lower the colposcope. The mobile base could be improved by enlarging the diameter of the wheels to make maneuvering the colposcope around power cords less difficult. Even with all of the stability knobs tightly secured, there is some free play in the stand, which decreases the stability of the colposcope during operation. The fine-focus adjustment is easy to use and operates smoothly. The dials are well placed, and the scope is user friendly. The 300-mm focal length allows adequate room for instrumentation. The electrical cord hangs between the colposcopist and the colposcope.

Visually, the illumination is very uneven. The area illuminated is less than the area observed for the 4 \times and 6 \times objectives. The illumination is neutral in color balance. In general, the Cabot 6000 colposcope is a quality product. The system evaluated is well suited for residency training programs because it maximizes the educational experience for the novice colposcopist. Cabot includes a 3-year warranty for parts and labor, which is above the standard coverage provided by the industry.

Olympus OCS-2

Olympus is well known for its flexible sigmoidoscope and nasal laryngoscope. The OCS-2 colposcope (Olympus Corporation, Lake Success, NY) complements this family of equipment with distinction. Many features of the Olympus scope demonstrate original research and design. The colposcope incorporates a zoom magnification system with an excellent range of 5.4 \times to 16.0 \times . The magnification changer indicates total magnification representing a 220-mm objective lens and not the 300-mm objective lens evaluated. The illumination system uses a halogen bulb, and a variable illumination-intensity control is included. Of note, as a unique safety feature, the power to the colposcope shuts off if the door to the light bulb is opened. The illumination system is a

cool light source, as fiberoptics transmit the light and a rather noisy fan adequately cools the distal bulb. The light source is interchangeable with other Olympus fiberoptic systems. Two objective lenses have been incorporated into the Olympus scope to provide true stereoscopic vision. The overall design is very user friendly with a flexible articulating arm. All dials for operation function quite smoothly, but the instrumentation room is slightly restricted by the handles that are located on both sides of the colposcope head.

The eyepieces contain reticles for assisting in focusing. The eyepieces have no neutral points for the diopter adjustment setting and no hoods. The eyepieces are positioned vertically rather than on a slant (usually approximately 45°), creating for the colposcopist the sensation of being closer to the subject or target area. The unprotected fiberoptic cable is placed in front of the colposcope and could easily become wound around the articulating arm. The wheels are too small, and there is no weighted base, which compromises the stability. The green filter is mounted on a sliding mechanism, which also contains a blue filter, yet the system is not internally located within the colposcope and could potentially collect vision-obscuring dust. The green filter also requires alternate hands to change the setting.

Visually, the light source is uneven and somewhat striated. The circle of illumination is greater than the area of view for all magnifications. The light source is somewhat cool. The OCS-2 colposcope is certainly competitive, incorporating many nice features and priced at approximately \$4800.

Jedmed SOM 2/5

Jedmed markets Kaps German-manufactured colposcopes. It quickly became obvious that Jedmed has a quality product within their line of colposcopes. The SOM 2/5 (Jedmed Instrument Co, St Louis, Mo) is a wall-mounted, multiple-magnification colposcope that uses a xenon coaxial light source. It has a variable illumination-intensity control. When the colposcope is lowered into the working position, the light is automatically activated. When not in use, the scope can be positioned out of the way along the wall. The wall-mounted system provides a degree of stability unsurpassed by any of the other styles. A single handle is located on the bottom of the colposcopic head. The freely movable articulating arm makes this colposcope one of the easiest to focus and adjust. The colposcope head features a three-dimensional degree of adjustable freedom that facilitates other types of microscopic examinations. Dials operate smoothly, with fine precision, and are strategically located, except for the fine-focus dial. The six-step range of total mag-

nification is excellent at 2.7× to 16.6×. The scope features only one objective lens, and no lamp fan is included. The optics are good and the colposcope is constructed of high-quality materials. The space for instrument manipulation is adequate.

Visually, illumination is even and the color is neutral. The circle of illumination does not cover the area of view when the colposcope is set at the lowest magnifications. At all other magnifications there are no illumination problems.

The Jedmed includes a 10-year warranty on parts and labor, excluding the fiberoptic cable and light bulbs. The SOM 2/5 would be an impressive addition to any practice.

Jedmed KP6/3

The KP6/3 colposcope is well constructed and very suitable for an office-based clinician. It is a multiple fixed magnification colposcope with a center-mount pole and a halogen light source. The three-step fixed magnification options, although potentially interchangeable with this colposcope, range from 4.2× to 10.6×. A five-step magnification is also available. The scope features a built-in iris to allow depth-of-field control. The colposcope body is flexible and permits multiple objective lenses, binoculars, and eyepieces. Even with only one objective lens, the optics are excellent. The fiberoptic system incorporates a variable illumination-intensity control. The fiberoptic cable is located in front and is not internalized for protection. The fan-cooled light bulb is easy to locate and replace. The overall stability is superior, largely because of the colposcope's weighted base. The wheels are slightly small, and the mobility, although good, could be improved. The colposcope holds position and focuses well. The dials operate smoothly and have been strategically placed. The eyepieces have hoods. The height-adjustment mechanism is excellent. Overall, the KP6/3 is very easy to use and allows plenty of room for instrumentation. The scope has accessory portals and is photographically adaptable. The particular colposcope evaluated was missing a caster lock, and the fine focus initially came off its track. The scope is compact and durable. Priced just under \$5000, the KP6/3 provides value for the money.

Frigitronics Zoom 310

The Frigitronics Zoom scope (Frigitronics, Shelton, Conn) features a halogen light source with variable-intensity control. The light source is the same as that used by the Jedmed KP6, but the fiberoptic cable is thicker in

diameter. The fiberoptic cable is located in front and is not internalized for protection. The zoom scope features an excellent magnification range, from $4.5\times$ to $17.4\times$. The 310-mm focal length of the scope is slightly long. The scope is very easy to use, and the room for instrumentation is superior. The clear optics are characteristic of the Japanese Nikon. The scope has one objective lens, and the fine-focus and height-adjustment controls are slightly tight. The knob for the coarse-height adjustment is small. The oculars are equipped with very comfortable eyepiece hoods, but the diopter adjustment has no reference scale. The scope holds position and focus. The dial locations are appropriate, except for the green filter. The green filter dial is tight and requires alternate hands to fully operate. An excellent support system with a broad base and superior wheels and casters provides the best mobility of any of the instruments evaluated. Caster locks are on all five wheels.

Visually, the illumination is somewhat warm. At the lowest magnifications, the illumination circle is smaller than the area viewed. The illumination is uneven at all magnifications. An extended 4-year warranty is available if payment is made within 30 days of purchasing the colposcope. The Frigitronics zoom scope has many outstanding features and is well designed.

Frigitronics 280

The Frigitronics 280 scope is a single-magnification colposcope with a center pole support and an incandescent light source. The scope evaluated has a single fixed magnification at $16\times$; however, magnification options are available at $12.8\times$, $24\times$, and $32\times$. There is a variable illumination-intensity control, and the light bulb is well located to facilitate changing. The 50-watt maximum incandescent illumination light source projects an impure white image and is insufficient to provide adequate illumination. The lamp housing becomes quite hot during use because of the lack of a cooling fan. The electrical cord for the light is located between the colposcopist and the scope itself. The colposcope has two objective lenses and a portal to accommodate optional equipment. The 280 scope, like the zoom 310 scope, features a well-designed, lightweight, five-leg base that provides excellent stability and mobility. The colposcope holds focus and position. The appropriate dials are easily adjusted. The eyepieces have hoods. There is no diopter scale on the ocular eyepieces. The green filter has a roll switch that cannot be grasped between the fingers or with the hand. The fine height adjustment tightens poorly and gradually slips. The room for instrumentation is restricted because of the 280-mm objective lens focal length. Visually, the illumination is even, and the circle of illumination is

greater than the area of view. The visual color of illumination is slightly cool.

The overall optics are very good, but the colposcope demonstrates some design weaknesses.

Zeiss ZMS-501-11

Zeiss is known for its first-class microscopic and optical equipment. The ZMS-501-11 (Carl Zeiss, Inc, Thornwood, NY) is no exception. The colposcope has a multiple fixed three-step total magnification range from $6.2\times$ to $16.4\times$. The scope features a halogen light source with a variable illumination-intensity control and fiberoptic cables. Both the bulb and fuses are easy to locate and replace. The optics are excellent but the scope lacks a fine-focus dial. The optional video system is of excellent quality and would be a splendid addition to any training program or operating room; however, the video system compromises the necessary room for instrumentation. The stability and mobility are excellent; the weighted base is second to none. The scope holds position and focuses quite well, and most dials are well located. The scope is laser adaptable.

Visually, the illumination is even but does not cover the entire field of view. This is especially noticeable at lower magnifications. Visual color is very warm. Zeiss scopes are frequently found in hospital operating rooms throughout the country, evidence of their immense popularity among sophisticated colposcopists.

Zeiss ZMS 506-11

The Zeiss 506, like the 501, is another high-quality, durable colposcope. The scope has a multiple fixed five-step magnification range between $3.4\times$ and $21.0\times$. The illumination system source is halogen, with a fiberoptic cable and a variable illumination-intensity control. The scope features unsurpassed Zeiss stability, due again to an excellent weighted base. Yet the wheels are slightly small for the overall size of the colposcope. The scope holds position and focuses well. The dials are located well, although the magnification changer dial is small. The room for instrumentation is outstanding. The light source and fan are located in the arm. The green filter, power supply, and coaxial light-source intensity switches are integrated in the arm, slightly removed from the operations area. The coaxial illumination is transmitted through the well-protected fiberoptic cable, thus the heat source is isolated from the operator and patient. The angular mount, IFC microscope head configuration for the ocular lens makes observation through the scope easy, and the overhead swinging arm makes focusing and adjustment simple.

High eyepieces for spectacle wear or eye hoods are present to eliminate the black-ring effect.

Visually, the illumination is uneven. The circle of illumination is just barely adequate at low power; at higher powers it is sufficient. The color is neutral.

Of note, Zeiss repairs instruments on site; equipment is seldom returned to the factory. This colposcope is first-class.

The Wallach Zoom Scope

The versatile Wallach Zoom scope (Wallach Surgical Devices Inc, Milford, Conn) is a zoom magnification scope with a total magnification range of $3.5\times$ to $15\times$. It uses a halogen bulb and fiberoptic cable, and is equipped with a variable illumination-intensity control switch. The unit is somewhat top-heavy but is supported by a broad three-roller base. The stand would do better with a weighted base and larger wheels. The Nikon optical colposcopic head can be rotated and repositioned to facilitate androscopic examinations. The scope may also be used as an operating microscope. The colposcope holds position and focuses well. The eyepiece hoods are very comfortable. The scope features a unique tension adjustment for fine focusing. The fine-focus knob is large and provides ease of use. The diopter adjustments have no reference scale, however. The wonderful overhead articulating arm enables superior space and room for instrumentation. The Nikon colposcopic head is the same as the Frigitrionics ZM 310. The optical characteristics are excellent. The green filter is externally located and, as a result, dust could collect on the lens.

The light source does not cover the field of view at low magnifications. The illumination is uneven at all magnifications. The color is visually neutral.

The Wallach Zoom scope is well designed, incorporating many nice features, and would have many useful applications in a private practice.

Wallach Colpostar V6

The Colpostar V6 is a single-magnification, center-pole-mounted colposcope with a tungsten light source. There is a three-step illumination-intensity control switch, and no fiberoptics are used. The mobility and stability are poor because of the nonweighted, rather narrow diameter base. The scope holds focus well, but does not hold position well. The fine focus performs poorly. Overall, the dials, compared with other colposcopes, do not function as smoothly. The short 275-mm focal length inhibits instrumentation room. The scope evaluated has a magnification of $13.5\times$, which is good for cervical examina-

tions but does not allow sufficient range for other perineal and treatment applications. The colposcope is adaptable for accessory options. The optics are considered good except for the brightness, which even at the highest light-intensity setting is not of equal intensity to other colposcopes. The materials used overall are of poorer quality than other scopes. The eyepieces or oculars are interchangeable to alter magnification. The electrical cord is located between the colposcopist and the colposcope. The lightweight scope has two objective lenses and features ocular reticles.

Visually, the circle of illumination is greater than the areas of view. The visual illumination is even and neutral in color. It is not possible to take photographs through this unit.

The Colpostar V6 is an inexpensive basic scope; however, its durability is questionable.

Leisegang IDL

Leisegang colposcopes (Leisegang Medical Inc, Boca Raton, Fla) are German-manufactured, well designed, functional, and practical. The construction materials used are superior to those used by most other manufacturers. There is a wide variety of Leisegang colposcopes available to purchase. The seemingly unlimited options and configurations can be mildly overwhelming and confusing for the novice colposcopist. The IDL is well suited for a private-practice physician. The scope is a three-step multiple fixed magnification colposcope ranging in magnification from $3.5\times$ to $14.0\times$, with a center base and unique tilt stand. The colposcope uses a halogen light source without a fiberoptic cable and has a variable illumination-intensity control knob. Mobility is less than optimal because of the lack of a wheelbase. The scope is lightweight but would need to be carried from room to room. The scope holds both position and focus well, and the dials have been strategically placed and operate smoothly. The room for instrumentation is excellent, and the overall ease of use is good. The colposcope is laser-adaptable and also can be supplied with a video system. The optics are first-class. The colposcope uses two objective lenses that give a clearly magnified stereoscopic image. Leisegang features a 5-year warranty on parts and a 1-year warranty on labor. The IDL is an excellent colposcope, yet is slightly more expensive compared with similar models by other manufacturers.

Leisegang 3BD

The 3BD is a multiple three-step fixed magnification colposcope with a "swingomatic" articulated arm sup-

port system. The colposcope has a total magnification range of $7.5\times$ to $30\times$, but this can be altered. The colposcope uses a halogen bulb with no fiberoptics but does include a variable illumination-intensity control. The colposcope has no light fan. The stand and support are first-class and the stability is excellent. The scope holds both position and focus well, and the location of the dials is superb. The large magnification changer dial is easily grasped. The coarse-height adjustment is not as well designed as that of other colposcopes. The ease of use and room for instrumentation are excellent. The Leisegang scope features a field-of-vision calibration reference scale that is useful for laser or cryosurgical measurements. The 3BD is a sturdy colposcope and constructed with high-quality materials.

The scope is of true stereoscopic design and the optics are superior. The illumination source is visually neutral and of sufficient size and evenness.

The 3BD is a quality multifeatured scope that is able to nicely perform most colposcopic-related tasks.

Medgyn AL-102

The Medgyn AL-102 (Medgyn Products Inc, Downer's Grove, Ill) is the least expensive colposcope evaluated. The scope is lightweight and features a variable three-step illumination-intensity control with an incandescent bulb. There is no light fan with this model. The scope is a single magnification scope, although various oculars can be purchased to change magnification. The scope is mounted on a center post, and the mobility and stability are rather poor. In fact, the lower unit is exactly the same as the Wallach Colpostar V6 model. The unit is top-heavy and could be easily damaged. The scope holds position satisfactorily and holds focus well. The fine-focus is very tight. Like the Colpostar V6, the AL-102 is difficult to grossly position for coarse focus if the scope is pushed from the top. Dials are also tight and are not as smooth to operate as those on other more expensive models. The eyepieces have no hoods. The scope features a 275-mm focal length, which compromises instrumentation space. The scope is easily used, although the oculars must be changed in order to change magnification. The scope has video and photographic capabilities. The quality of the optics is fair, the brightness is poor, and the construction materials are inferior to others. The colposcope has a very small field of illumination at 25 mm. There is a field-of-view reference within the oculars; however, the reference distance diameters are not re-

corded. The colposcope does feature two objective lenses for better field depth and stereoscopic vision. The portal for photography is created by removing one eyepiece. The feature is a bit cumbersome, as there is no accessory portal. The electrical cord is also placed between the colposcopist and the colposcope.

The AL-102 colposcope is essentially a pair of binoculars. The illumination is visually even, with a circle of illumination greater than the field of view. The Medgyn colposcope's durability is questionable; however, it is the most economical of the colposcopes evaluated.

Recommendations

The colposcope review, although selective and limited in total number of scopes, is comprehensive and detailed compared with prior review articles. It would be difficult to simultaneously critically evaluate all of the colposcopes currently available for purchase in the United States. This feature evaluation may facilitate the informed selection of other colposcopes not included here. The knowledge of colposcopes acquired may benefit practicing physicians or novice colposcopists participating in training programs who are contemplating purchasing a colposcopic instrument. The authors admittedly had difficulty in comparing colposcopes because of the many different features and accessories available. The ultimate choice is left to the individual physician and should be made after making a careful needs assessment and critical equipment appraisal. The most important characteristics to consider are that the colposcope be of high-quality, durable construction with sharp, clear optics. Functionally, the colposcope must conform to or adapt to the practice characteristics of the colposcopist. Finally, colposcopy can be performed with any of the colposcopes evaluated. Some colposcopes simply facilitate the procedure better than others.

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