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# Arthroscopy of the Knee

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# The Evolution of Arthroscopy

As we learn arthroscopic technique, it is valuable to know the evolution of the arthroscope and its historical application. Originally, endoscopic techniques were developed to look into the bladder and body cavities. After this application arthroscopy progressed to the knee and other synovial joints.

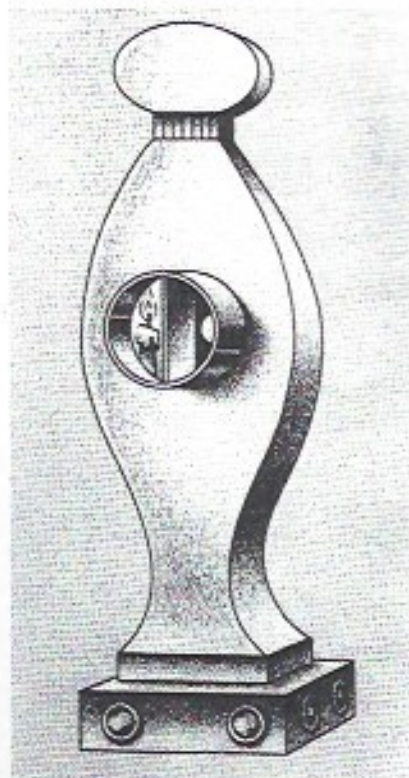
Modern endoscopy began when Bozzini (1773–1809) of Frankfurt devised his "lichtleiter" or light conductor in 1806<sup>25,29,38</sup> (Fig. 1–1). The original instrument was a bifid tube attached to a light chamber. The light source was a candle that reflected light into a body cavity by means of a concave mirror and speculum. Through the back of the instrument there was a small aperture, so that the cavity could be visualized. Bozzini mainly used his device to examine the vagina and rectum. This primitive device was presented to the Joseph Academy of Medical Surgery in Vienna in 1806; the Academy considered it merely a toy and of no importance in the examination of the urologic system.

A few years later, Pierre S. Segalos (1792–1875) in France utilized the same principle of light conduction as Bozzini had, but instead of a concave mirror he used a conical one to introduce the light into the urethra and the interior of the urinary bladder. The procedure was demonstrated to the Royal French Academy, but the illumination was poor and the instrument found little acceptance.<sup>25,29</sup>

A.J. Desormeaux (1815–1882) introduced the cystoscope in 1853 and became the first surgeon to gain acceptance of his endoscopic instrument as a valuable diagnostic and therapeutic tool in urology.<sup>25,29</sup> The light source, called a "gazogene lamp," used a mixture of turpentine and alcohol (Fig. 1–2). A concave perforated reflector directed the light down a series of silver tubes and mirrors. The surgeon looked through an eyepiece into the bladder and urethra. Publication of Desormeaux's work established the value of the cystoscope.

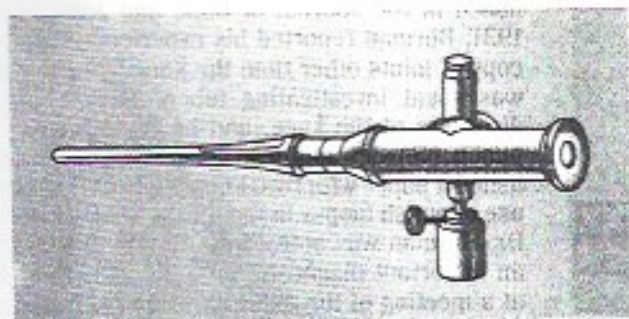
In 1867, J. Andrew improved the light source with the development of a magnesium filament that pro-

duced a strong white light. This was the best external light source at the time. Julius Bruch, a Breslau dentist, was the first to introduce the light source into a body cavity. He inserted a platinum filament into the rectum, illuminating the urinary bladder, which he inspected through a speculum. A great disadvantage was the heat generated by the lamp.<sup>25,29</sup>



**Figure 1–1**

The Bozzini lichtleiter. (Reproduced with permission from The Upjohn Company and Joyce JJ III: *History of arthroscopy*. In O'Connor RL (ed): *Arthroscopy: A Scope Publication*. Kalamazoo, MI, The Upjohn Company, 1977.)

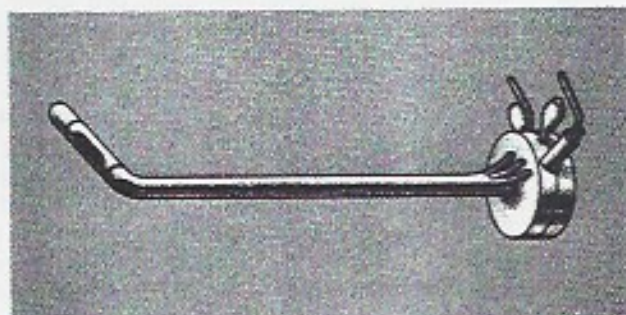


**Figure 1-2**

The Desormeaux gazogene endoscope. (Reproduced with permission from The Upjohn Company and Joyce JJ III: History of arthroscopy. In O'Connor RL (ed): Arthroscopy: A Scope Publication. Kalamazoo, MI, The Upjohn Company, 1977.)

The German physician Max Nitze (1848-1906) recognized the difficulties with an externally reflected light source and in 1876 designed an instrument with a combined light source, reflector, and scope (Fig. 1-3). The instrument consisted of a platinum loop encased in a goose quill, which introduced light directly into the bladder. A flow of water along the instrument protected the tissues, and an improved lens system provided better visualization. He demonstrated his instrument before the Vienna Medical Society of Saxony in October 1879, but was heavily criticized for his "fire and water" invention.<sup>25,29</sup>

With Edison's invention in 1880 of the incandescent lamp, a filament in a glass tube, a more effective light source became available for use with the cystoscope. By 1886, Leopold Van Dittel (1815-1898), a Viennese surgeon, incorporated a mignon lamp into his cystoscope. Nitze, in association with the instrument maker Joseph Leiter (1830-1892), designed a cystoscope that not only had improved illumination but also a better angle of view and a larger field of vision. In 1890, R. Kutner and Nitze introduced the photocystoscope and took the first endoscopic photographs of the bladder. The Zeiss Company in 1907 improved optics with the Amici prism. This produced



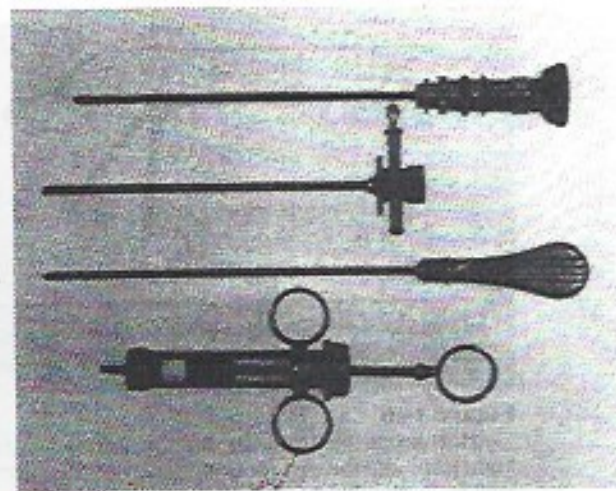
**Figure 1-3**

The Nitze endoscope. (Reproduced with permission from The Upjohn Company and Joyce JJ III: History of arthroscopy. In O'Connor RL (ed): Arthroscopy: A Scope Publication. Kalamazoo, MI, The Upjohn Company, 1977.)

a vertical and sharper image. Before this improvement the image was always inverted. Not until the turn of the century did the cystoscope become an important urologic tool.<sup>25,29</sup>

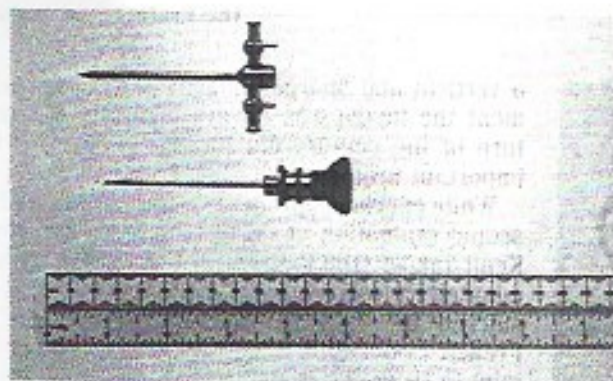
While enormous progress was being made in endoscopic evaluation of the urologic system, Professor Kenji Takagi (1883-1963) of the University of Tokyo adapted endoscopy to the knee joint. He must be considered the father of arthroscopy. Using a #22 French cystoscope, he examined a cadaveric knee joint in 1918. The first "arthroscope" he designed, in 1920, was 7.3 mm in diameter. It contained no lens system but had an incandescent bulb at the tip (Fig. 1-4). The large diameter of the scope made it impractical for examination of the knee joint, but nevertheless he was successful in examining a tuberculous knee. Impressed with the clear view that he was able to achieve with the arthroscope, Takagi concentrated on reducing its diameter. By 1931, he had achieved a diameter of 3.5 mm; subsequent models were even smaller and required a lens system to magnify the images. The original impetus had been to diagnose tuberculosis of the knee, and by the mid 1930s Takagi was able to perform synovial biopsies with a 4-mm (#12) arthroscope. He later introduced a 5-mm (#13) arthroscope that incorporated a forward, oblique, and side viewing lens. In 1936, Takagi took the first reported color photographs of the knee joint, using a 6-mm arthroscope.<sup>13,44</sup>

Independently of Professor Takagi, Eugene Bircher of Switzerland in 1921 used a Jacobeus laparothoroscope to examine the knee joint. He published the results of 20 arthroscopic examinations in 1922. What stimulated Bircher's interest in "arthro-endoscopy" was the disappointing experience with clinical and radiologic diagnosis of knee lesions. Bircher performed arthroscopy under strict aseptic technique.



**Figure 1-4**

The first Takagi arthroscope. (Reproduced with permission from The Upjohn Company and Joyce JJ III: History of arthroscopy. In O'Connor RL (ed): Arthroscopy: A Scope Publication. Kalamazoo, MI, The Upjohn Company, 1977.)

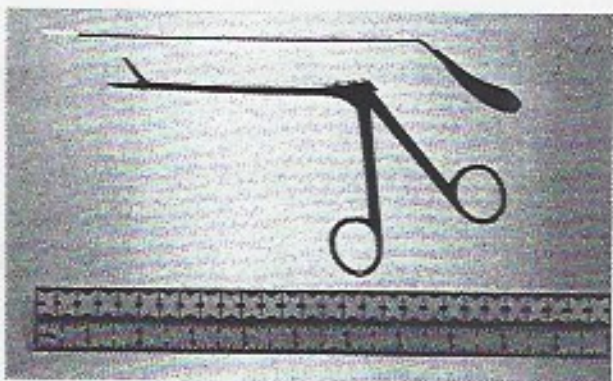


**Figure 1-5**

The Burman arthroscope. (Reproduced with permission from The Upjohn Company and Joyce JJ III: History of arthroscopy. In O'Connor RL (ed): Arthroscopy: A Scope Publication. Kalamazoo, MI, The Upjohn Company, 1977.)

He soaked the arthroscope in 96 percent alcohol for 2 to 3 minutes before and after each procedure. Between cases he stored the arthroscope in a chamber of formalin fumes. The knee joint was distended with oxygen and carbon dioxide, yet he found his examination to be hampered by the cruciate ligaments. In his publications Bircher reported that "arthro-endoscopy" was superior to all other methods of knee joint examination,<sup>1</sup> but he was unable to photograph the interior of the knee joint. In 1925, Philip Kreucher became the first American to report on the use of the arthroscope to diagnose meniscal lesions.<sup>30</sup>

In the early thirties, at the Hospital for Joint Diseases in New York, Drs. Maycr, Finkelstein, and Burman published a number of significant monographs on the subject of arthroscopy.<sup>2-6,12</sup> Dr. Michael Burman (1901-1975) used an arthroscope designed by Mr. R. Wappler that had a trochar 4 mm in diameter, a telescope 3 mm in diameter, and a lamp incorpo-



**Figure 1-6**

Arthroscopic instruments for the Burman arthroscope: knife (top) and forceps (bottom). (Reproduced with permission from The Upjohn Company and Joyce JJ III: History of arthroscopy. In O'Connor RL (ed): Arthroscopy: A Scope Publication. Kalamazoo, MI, The Upjohn Company, 1977.)

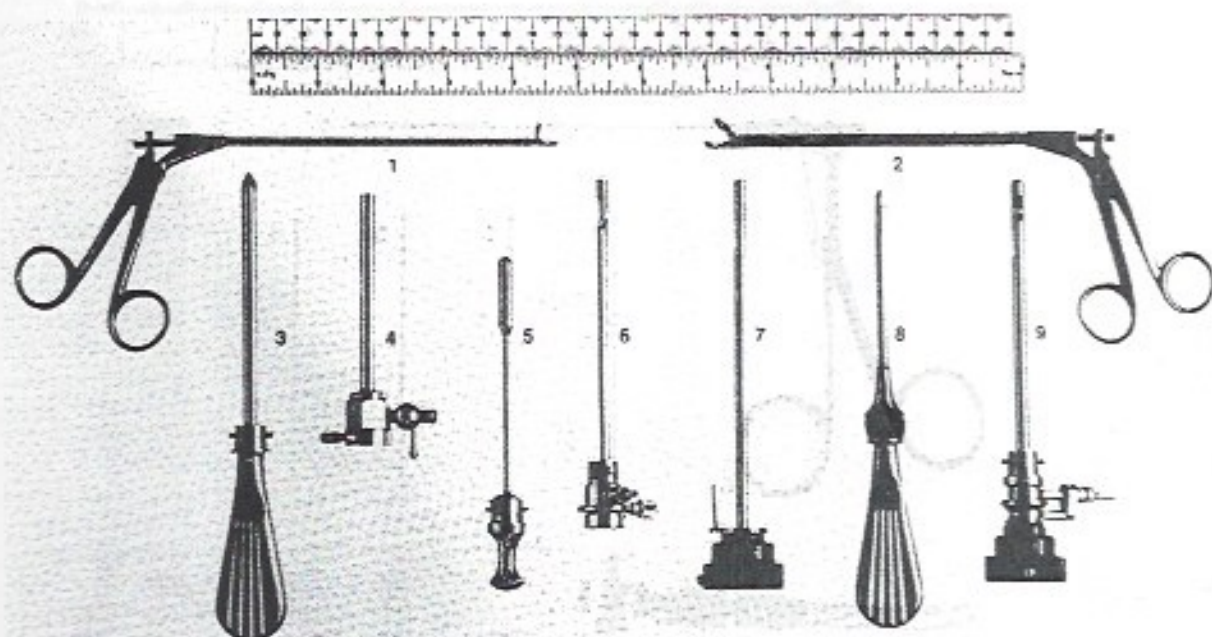
rated into the shaft, and allowed constant irrigation (Figs. 1-5 and 1-6). In a classic manuscript published in the *Journal of Bone and Joint Surgery* in 1931, Burman reported his experience with arthroscopy of joints other than the knee.<sup>2</sup> Most of his time was spent investigating tubercular or sarcoid-like disorders of the knee, and he was able to perform punch biopsies of these lesions. In 1936, he published a paper with Drs. Finkelstein and Mayer on the use of punch biopsy in the diagnosis of tuberculosis.<sup>4</sup> Dr. Burman was active in promoting arthroscopy as an important diagnostic tool and exhibited his work at a meeting of the American Medical Association in Cleveland in 1934, at the Third Annual Meeting of Orthopedic Surgeons in New York City in 1935, and at the New York Academy of Medicine in 1936.<sup>38</sup>

In Germany, studies on arthroscopy of the knee were published by Sommer in 1937<sup>42</sup> and Vaubel in 1938.<sup>46</sup> Sommer used the Grave arthroscope and felt that it was a valuable tool in the diagnosis of tuberculosis. He believed that arthroscopy of the knee could be repeated several times without inconvenience to the patient. Vaubel advised arthroscopic examination of the knee for many disorders in order to avoid exploratory arthrotomy.

Interest in arthroscopy revived after World War II, when in 1955 in the French literature E. Hurter described arthroscopy as a "new" method of examining joints.<sup>8</sup> R. Imbert in 1956 and 1957 published further papers in France on the subject of arthroscopy.

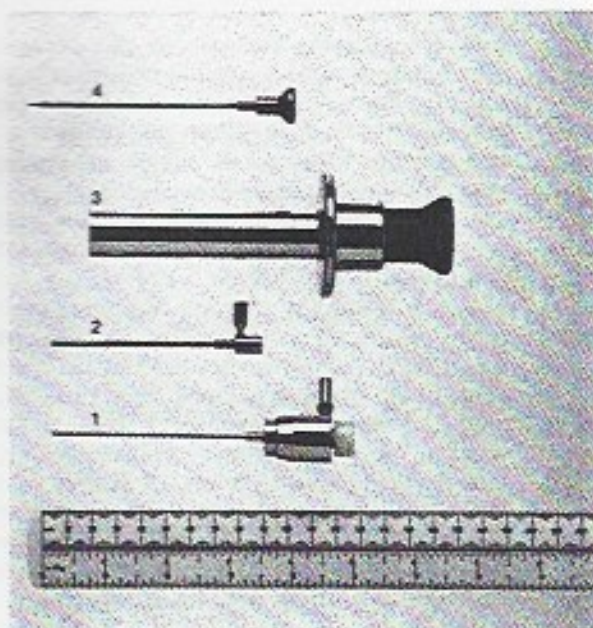
Dr. Masaki Watanabe, a pupil of Takagi resuming his mentor's work, developed better instruments and a more reliable lighting system. He also continued Takagi's numbering system for the arthroscope. Until 1959, arthroscopy of the knee joint, including the first surgical arthroscopy, used a #13 arthroscope. Working through trial designs #14 to #20, Dr. Watanabe and Dr. Takeda designed the #21 arthroscope (Fig. 1-7) and described its use in 1960.<sup>50</sup> The Watanabe #21 arthroscope had a diameter of 6.5 mm, a field vision of 100 degrees, and a tungsten light source. It is generally considered that most Americans developed their arthroscopic skill initially with the #21 arthroscope.

The first arthroscopic surgery was performed by Dr. Watanabe on March 9, 1955, when a partially necrotizing xanthomatous giant cell tumor was removed from a patient's knee joint. On February 22, 1961, an osteochondral loose body was extracted arthroscopically after a patellar dislocation, and the first partial meniscectomy was performed by Dr. Watanabe on May 4, 1962.<sup>47,49</sup> Watanabe's original work was published in the *Atlas of Arthroscopy* in 1957, with the second edition (1969) based on 800 cases using the #21 arthroscope.<sup>51</sup> Not yet finished, in 1973 Watanabe presented a preliminary report on the "Selfoc Needlescope," a fiberoptic instrument with a diameter of 2.2 mm and 1.7 mm (Figs. 1-8 and 1-9), useful in the examination of small synovial joints.<sup>49</sup>



**Figure 1-7**

The Watanabe No. 21 arthroscope and arthroscopic instruments: biopsy forceps (1,2); trocar (3); sheath (4); obturator (5); bulb carrier (6); direct viewing scope (7); accessory trocar (8); right angle scope (9). (Reproduced with permission from The Upjohn Company and Joyce JJ III: History of arthroscopy. In O'Connor RL (ed): *Arthroscopy: A Scope Publication*. Kalamazoo, MI. The Upjohn Company, 1977.)



**Figure 1-8**

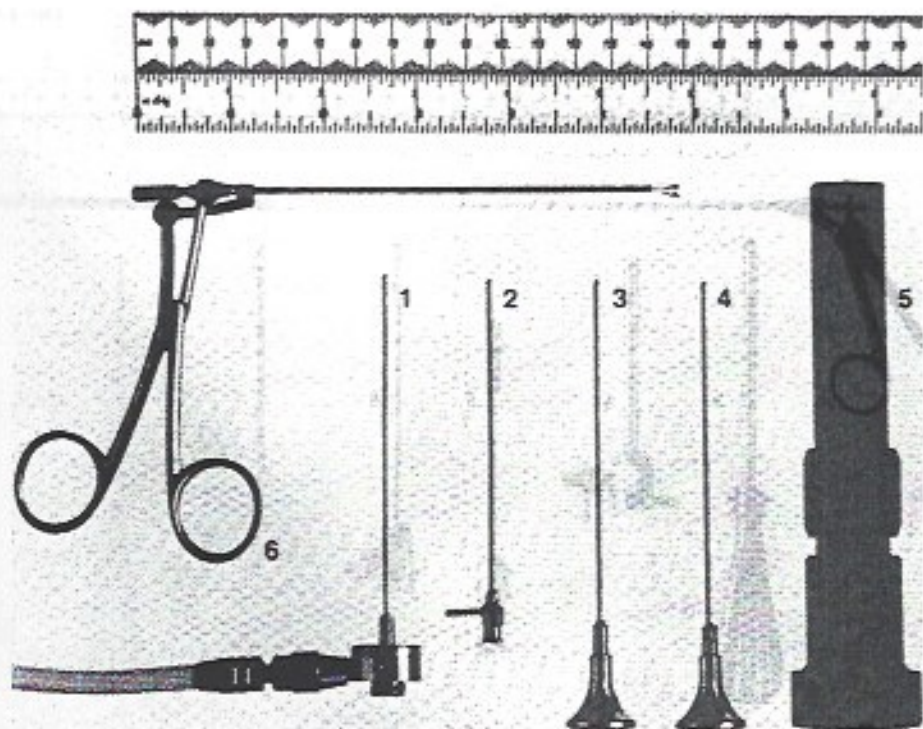
The Watanabe Selfoc 2.2-mm arthroscope: objective lens (1); sheath (2); magnifying lens (3); obturator (4). (Reproduced with permission from The Upjohn Company and Joyce JJ III: History of arthroscopy. In O'Connor RL (ed): *Arthroscopy: A Scope Publication*. Kalamazoo, MI. The Upjohn Company, 1977.)

The needlescope marked the beginning of the virtual explosion in arthroscopy of the 1970s and 1980s. The tremendous technologic and surgical advances were matched only by the ever-increasing interest of the orthopedic surgeon. In 1968, only 13 surgeons in the United States and Canada owned arthroscopes; by the early 1980s, over 98 percent of orthopedic surgeons used arthroscopy.<sup>27</sup>

Among the few practicing arthroscopists in America in the early 1970s, Robert Jackson was a most active contributor to the field.<sup>28</sup> He presented a review of 200 cases at the combined meeting on arthroscopy in Sydney, Australia, in 1970,<sup>23</sup> and he started to teach courses at the American Academy of Orthopedic Surgeons in 1968.<sup>23</sup> That same year Casscells reviewed 150 arthroscopic cases.<sup>7</sup>

The needlescope of Watanabe that became commercially available in 1972 marked the first in a series of technical innovations that made arthroscopy more worthwhile and popular. In 1973, the first course in arthroscopic surgery in the United States was given at the University of Pennsylvania, chaired by J. Joyce and attended by 75 people.<sup>28</sup> The following year Watanabe was elected the first president of the International Arthroscopy Association.<sup>28</sup> Also at that meeting, closed-circuit television was used for the first time as a teaching tool. J. McGinty gave the first AAOS course in knee arthroscopy utilizing video monitoring in 1975 and later introduced the use of television in performing arthroscopy<sup>32</sup> (Fig. 1-10).

Back in 1972, Lanny Johnson performed his first



**Figure 1-9**

The Watanabe 1.7-mm arthroscope: objective lens (1); sheath (2); trocar (3); obturator (4); magnifying lens (5); biopsy forceps (6). (Reproduced with permission from The Upjohn Company and Joyce JJ III: History of arthroscopy. In O'Connor RI, (ed): Arthroscopy: A Scope Publication. Kalamazoo, MI, The Upjohn Company, 1977.)

knee arthroscopy using local anesthesia and by 1975 had accumulated 400 such cases.<sup>26</sup> Bircher and Clayton were also advocates of local anesthesia.<sup>27</sup>

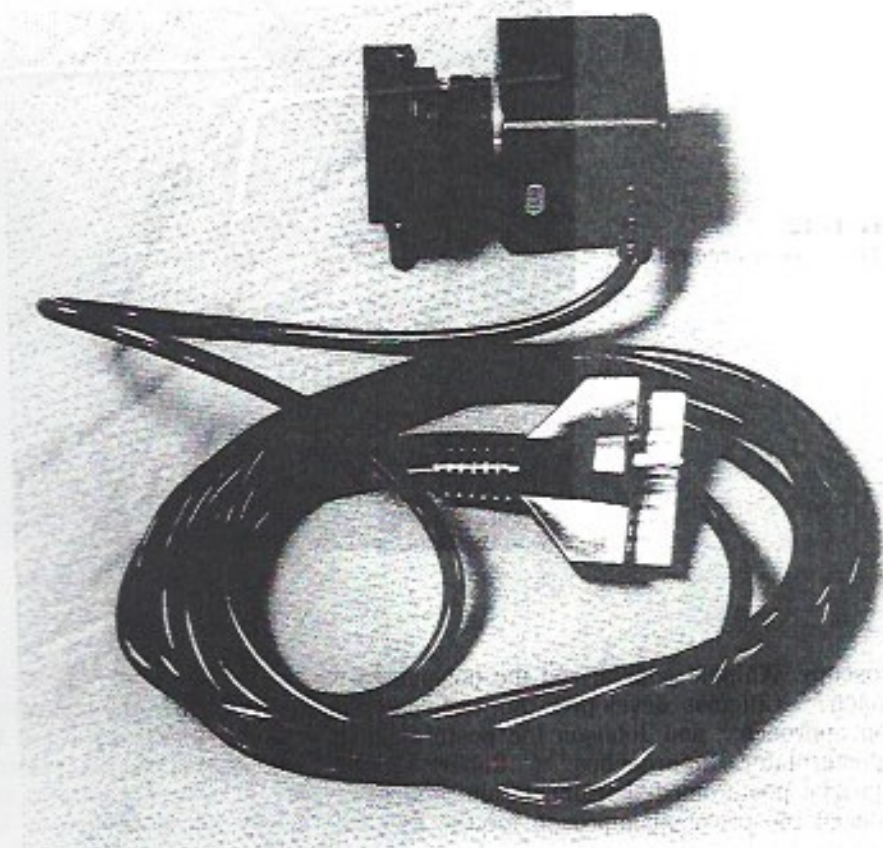
In 1974, Richard O'Connor introduced the first rod lens type of operating arthroscope, which has an offset eyepiece to allow for the passage of surgical instruments; this changed the course of arthroscopy, from a diagnostic to a surgical procedure.<sup>23,27,37,41</sup> In 1974, O'Connor removed the first osteochondritic loose body via the arthroscope.<sup>27,37</sup>

In the ensuing few years, O'Connor and H. Ikeuchi of Japan popularized the role of arthroscopy to include meniscectomy and meniscal repairs.<sup>22,37,41</sup> McGinty published their results of total and partial meniscectomies during this time.<sup>33</sup> Arthroscopic meniscal repair introduced by Ikeuchi was further developed by Clancy, Hennings, Mulholland, and others.<sup>9,11,19</sup> Hennings showed that intrasubstance tears did not heal as well as peripheral tears.<sup>18</sup> As surgical techniques developed in the mid and late 1970s, so did instrumentation. Wolf and Storz developed arthroscopes that supersede the #21 arthroscope of Watanabe because of superior optics and durability. By the late 1970s, the 30-degree, 4-mm arthroscope was the standard<sup>27</sup> (Fig. 1-11). In addition to im-

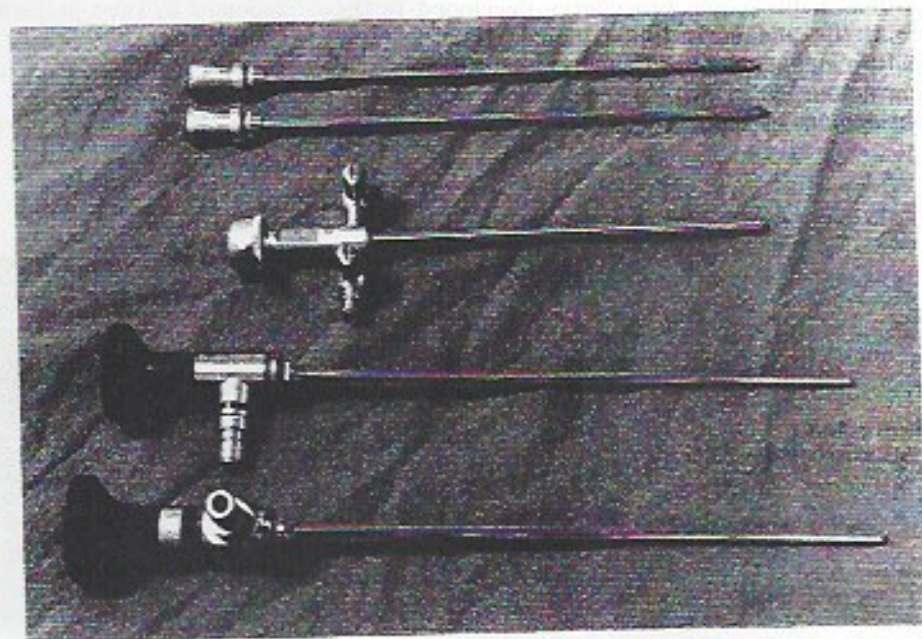
provements in the arthroscope, the surgical instruments improved. The original instruments were borrowed from neurosurgeons and gynecologists and quickly were developed into newer probes, baskets, and punches with various angles and configurations specifically for knee arthroscopy (Figs. 1-12 and 1-13). New surgical blades were developed for arthroscopic use that are stronger and resist breakage (Fig. 1-14).

Meniscal surgery was not the only surgical technique developed in the 1970s. In 1975, pinning of osteochondritic lesions and in 1978, bone grafting via arthroscopy were developed.<sup>17</sup> In 1976, shelf excisions became quite popular.<sup>10</sup> In that same year Johnson, in conjunction with Dyonics Corporation, introduced the first motorized shaver instruments (Fig. 1-15), which led to the arthroscopic treatment of patellofemoral disorders and degenerative arthritis.<sup>27</sup> The following year Watanabe introduced the first artificial knee joint for arthroscopic teaching purposes.<sup>48</sup>

This time period saw the development of various surgical approaches for knee arthroscopy. From the single portal approach, the development of multiple safe portal approaches was a great aid to operative

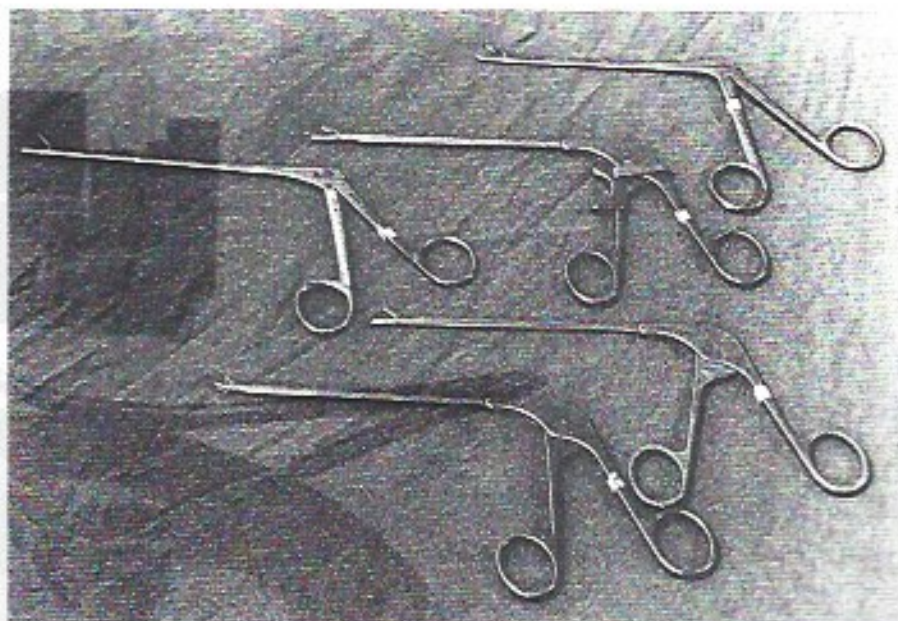


**Figure 1-10**  
Arthroscopic microchip camera.



**Figure 1-11**  
Wolf 4-mm 30-degree arthroscope, obturator, and trocars.

**Figure 1-12**  
Arthroscopic instruments.



arthroscopy. Whipple popularized the polypuncture approach.<sup>32</sup> Gillquist developed the transpatellar tendon approach<sup>26</sup> and Johnson the posteromedial and posterolateral approaches.<sup>15,27</sup> Robert Metcalf popularized posteromedial triangulation, and Patel introduced the proximal approach for the anterior horn of the lateral meniscus.<sup>27</sup>

In 1978, many orthopedists showed lateral retinacular releases to be a worthwhile procedure in treating patellar subluxation.<sup>18,34</sup> Medial retinacular repair for acute dislocation via the arthroscope was developed by Yamamoto,<sup>27</sup> and Austin introduced arthroscopic patellar realignment.<sup>27</sup>

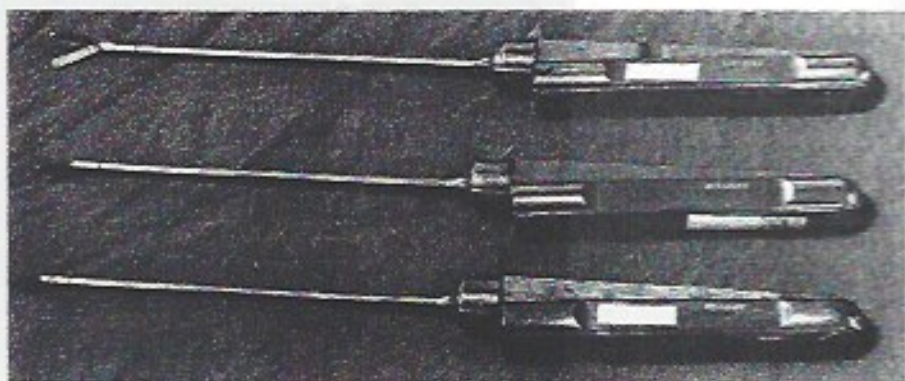
Other arthroscopic procedures developed in the late 1970s and early 1980s include tibial plateau fracture management by Caspari,<sup>27</sup> debridement and synovectomy in arthritic knees,<sup>27</sup> and arthroscopic debridement of septic knees.<sup>18,31</sup>

In 1980 and 1981, Mulhollan and Patel described the complications of arthroscopic surgery, revealing that arthroscopy of the knee is not a benign procedure but must be treated with respect.<sup>36,39</sup>

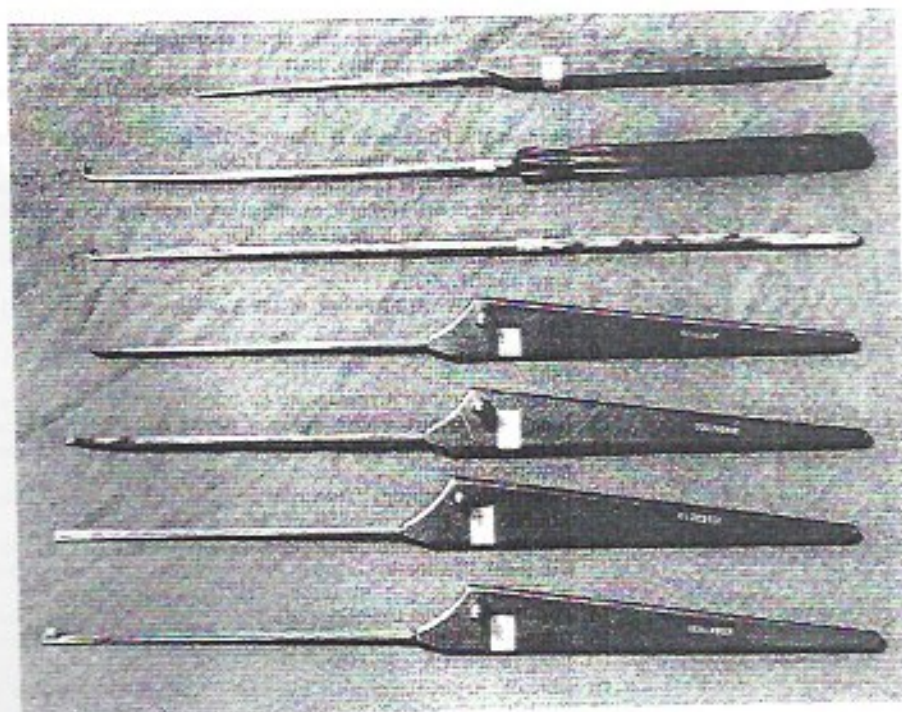
In 1981, Fox introduced the use of the electrocautery for arthroscopic lateral retinacular release. Whipple, Caspari, Smith, and Nanet investigated the use of lasers in arthroscopic knee surgery.<sup>53,54</sup>

The late 1970s and early 1980s began the era of arthroscopic ligament surgery. Takeda and associates reported on ligament reconstruction under arthroscopic control in 1977.<sup>45</sup> Chandler performed the first anterior cruciate ligament repair. This was followed by Drez performing an arthroscopic reconstruction of the anterior cruciate ligament with fascia lata graft and Dandy performing the first artificial ligament reconstruction using a carbon fiber ligament.<sup>31,34</sup> Presently, arthroscopic ligament recon-

**Figure 1-13**  
Arthroscopic instruments.



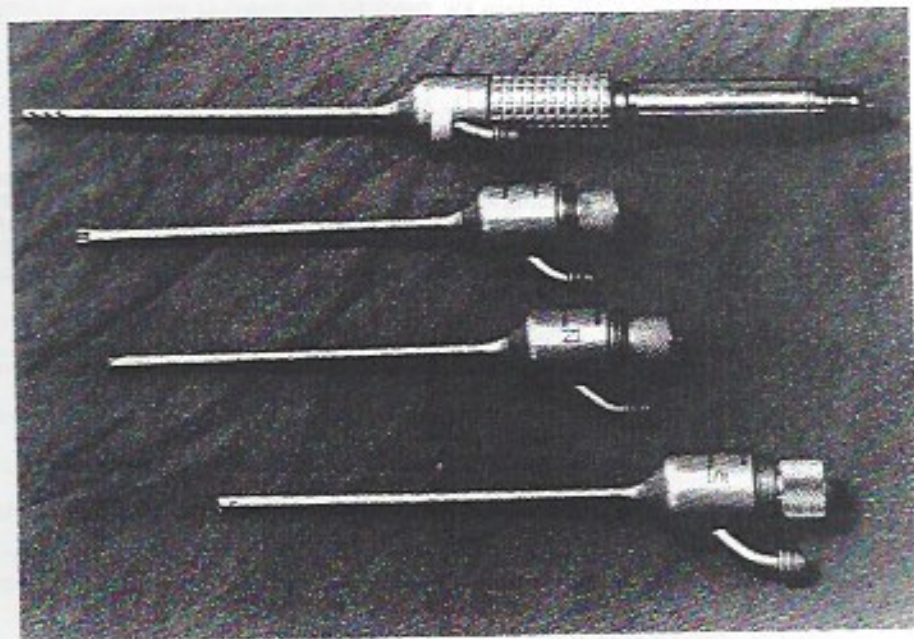




**Figure 1-14**  
Arthroscopic probes and knives.

struction has become popular with the use of autogenous grafts and allografts as well as synthetic artificial ligaments.<sup>13,35,40</sup> Arthroscopic ligament reconstruction has come into its own. With the multitude of techniques, instrumentation, and optics,

much of the surgical treatment for knee disorders, once performed open, can now be done entirely arthroscopically. Further refinement in techniques and new and improved instrumentation will be the foundation for the future of arthroscopy.



**Figure 1-15**  
Arthroscopic motorized shavers.

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