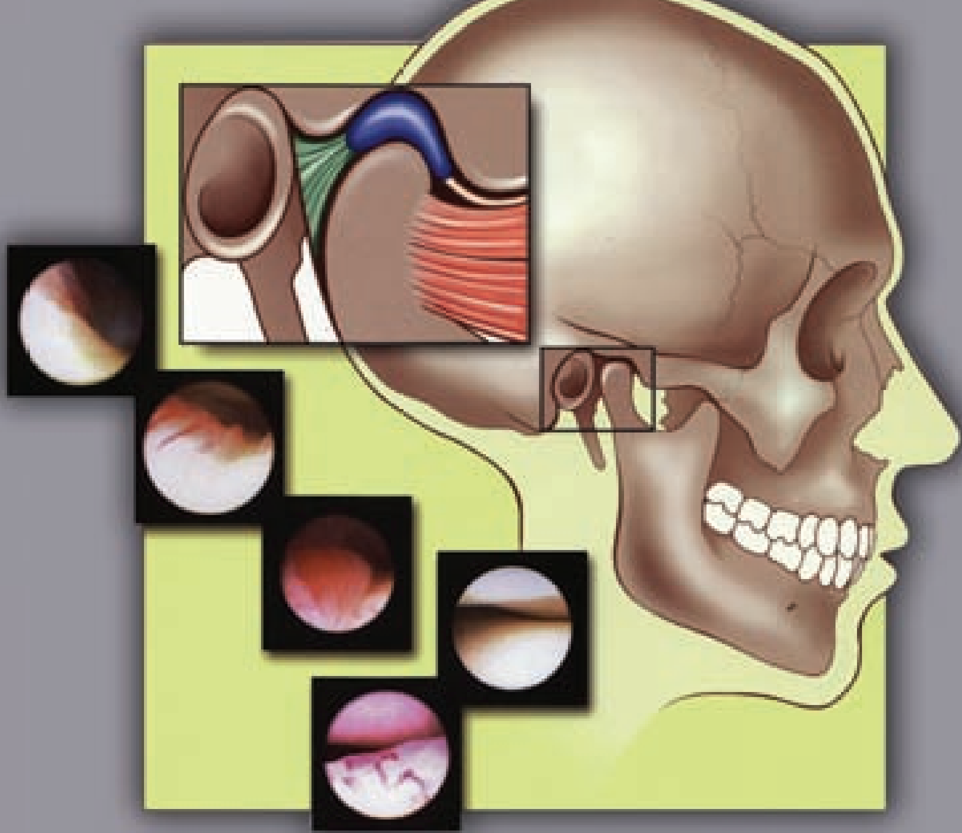
ARTHROSCOPY OF THE TEMPORO-MANDIBULAR JOINT



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1.0 Introduction

The surgical treatment of temporomandibular joint (TMJ) disorders presents us with an extremely complex and complicated set of interwoven problems that can raise difficult issues of diagnosis and treatment.
The great diversity of TMJ disorders results from the overlap between multiple organ systems and numerous functional processes, as illustrated in **Fig. 1.**

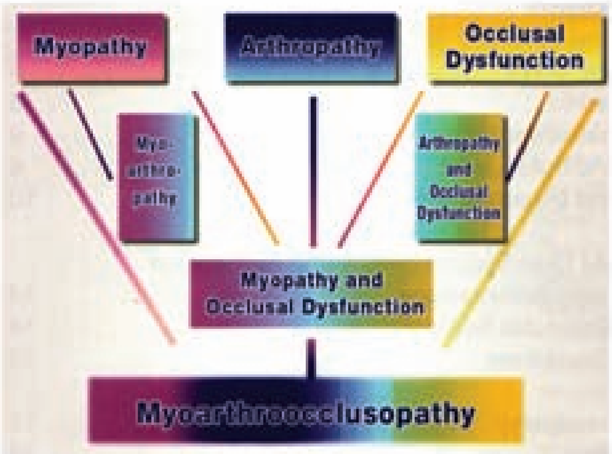


Fig. 1
The temporomandibular joint and associated disorders.

The following components may also play a role:

- *Craniomandibular dysfunction (CMD)*
- *Cerebral, neurological and psychiatric diseases*
- *Orthopedic diseases (e.g., of the cervical spine)*
- *Regulatory dysfunction, overloads, compensatory processes*
- *Age-related changes*
- *Decompensation due to changes in activity level or physical situation*

Proper patient selection is an essential foundation for successful surgical treatment. The principal indications for TMJ surgery are forms of craniomandibular dysfunction originating in the articular disc and the retrodiscal tissue (known also as the posterior attachment, posterior ligaments, or retrodiscal pad). The literature may be consulted for further details on these conditions.

As in all degenerative muscle, bone and joint diseases, surgical intervention should be elected sparingly and the primary treatment options are conservative. Surgical treatment is indicated in only about 5% of patients with TMJ disorders. Because TMJ operations are such specialized procedures, often it takes years to acquire adequate clinical experience.

Another factor that limits the indications for TMJ surgery is the miniscule size of the joint (about the size of a thumbnail). As a result, TMJ surgery and especially minimally invasive arthroscopic procedures are more technically demanding than procedures in larger joints, which are easier to access and explore. A major obstacle in mastering arthroscopic skills is the fact that operators cannot practice in human patients, while practicing in cadavers may do little to impart clinically relevant skills due to the altered consistency and appearance of the nonperfused tissues.

At our institution in Greifswald, we have solved the problem of safe TMJ arthroscopic training by developing an animal model that enables us to practice and teach a range of minimally invasive arthroscopic procedures in the TMJ. This is such an effective training tool that technical problems which subsequently arise in patients no longer limit the indications for TMJ arthroscopy.

Our objective in creating this guide to TMJ arthroscopy is to convey the experience that we have gained in our training model. Besides the basic principles of diagnostic arthroscopy, particular attention is given to the arthroscopic use of an innovative water-jet scalpel and to other arthroscopic techniques on the TMJ disc and retrodiscal tissue.

The simultaneous use of a surgical navigation system helps the operator to proceed more confidently and will one day make an important contribution to quality assurance in arthroscopic surgery of the TMJ.

In writing this monograph, we hope that we will be able to improve training to such as degree that a greater percentage of patients with TMJ disorders will become candidates for arthroscopic surgery, thus avoiding the large wounds of "open" surgical procedures and perhaps eliminating the risk of facial nerve injury.

2.0 Our Protocol for the Treatment of TMJ Disc Displacements

TMJ disc displacements and elongation of the retrodiscal tissue – referred to in the literature as "internal derangement," craniomandibular dysfunction, and secondary or functional TMJ disorders (*Gernet* and *Rammelsberg* 2002) – account for more than 90% of the TMJ cases that are referred to our center following a trial of conservative therapy. Almost all of these cases involve an anterior disc displacement with elongation of the retrodiscal tissue. Rarely, we may see posterior disc displacement in patients who have prognathic dentition or an habitually protruded jaw posture. It is also rare to encounter lateral disc displacements causing functional problems, and so this booklet deals mainly with anterior disc displacements with associated stretching of the retrodiscal tissue.

Most chronic, non-reducing disc displacements begin as an acute disc displacement. Thus, we repeatedly emphasize the importance of avoiding progression to more advanced stages of anterior disc displacement by initiating adequate treatment while the displacement is still in an acute stage.

With this in mind, we have developed a recommended treatment protocol at our center, which is outlined below. The guiding principle is that withholding treatment or providing conservative treatment for an acute disc displacement is appropriate only as long as the TMJ has not sustained chronic, irreversible damage.

We apply the following protocol in the treatment of acute, non-reducing anterior disc displacements at our center. Note that the primary treatment measures are conservative:

- **Immediate manual reduction** (aided by local anesthesia, intravenous sedation, or general anesthesia with muscle relaxation).
- **Next: 3 months of conservative therapy** (physical therapy, determining and establishing the centric position of the TMJ, splint therapy, pharmacologic therapy).
- **After an unsuccessful 3-month trial of conservative therapy:** reduction under arthroscopic control, arthroscopic shortening of the retrodiscal tissue.
- **Conservative treatment** is continued for up to one year after arthroscopic surgery, including the use of centric splints that protect the TMJ or widen the joint space (e.g., a bite guard that moves the mandible 1.5 – 2 mm forward). Myoarthropathy may be treated if necessary by injecting botulinum toxin into the affected musculature (e.g., the lateral pterygoid muscle).
- **Permanent correction to a centric jaw position** (the painless or least painful position of the mandible) should be considered at this stage as an alternative to life-long splint therapy. Options for permanent correction include orthognathic surgery, prosthetic treatment, and dysgnathic surgery.
- If the TMJ disorder has not improved or is worse by 12 months after the initial arthroscopic procedure, we recommend **further arthroscopic treatment** or even open surgery (e.g., open shortening of the retrodiscal tissue).

If the TMJ is not permanently corrected to a centric position, it is extremely likely that the TMJ changes will recur and that surgical measures on the disc and retrodiscal tissue will be unsuccessful. We believe that the timely initiation of appropriate treatment can reduce the incidence of serious TMJ disorders.

3.0 Diagnostic Arthroscopy of the Temporomandibular Joint

3.1 Indications and Contraindications

The principal indications for TMJ arthroscopy are functional complaints involving the TMJ in which clinical examination and imaging studies have not furnished a definitive diagnosis or non-invasive treatment modalities have not significantly improved the patient's complaints.

Indications for arthroscopy:

- *Disc displacement*
- *Disc deformity*
- *Intra-articular adhesions*
- *Degenerative arthritis*
- *Osteoarthritis*
- *Chronic forms of arthritis*
- *Post-traumatic changes*
- *Pseudotumors*

Arthroscopy is contraindicated in patients with acute infections, bony ankylosis, risk of tumor dissemination, general medical contraindications, and anatomical contraindications (*Blaustein* and *Heffez* 1990, *Murakami* 1989, *Ihnishi* 1990, *Reich* 1995). Rigorous patient selection is the key to a successful operation.

Fig. 2
Draping for TMJ arthroscopy.

3.2 Preoperative Preparations, Draping, and Instrumentation

Aseptic technique is a prime concern in TMJ arthroscopy. The patient should be draped in a manner that provides sterile access to both TMJs and to the puncture sites that will be marked on the skin. The drapes should also allow free access for passive opening and closing of the jaw by the operator. This is best accomplished with a combination of sheets and plastic film drapes (**Fig. 2**).

Prophylaxis of swelling and prophylactic antibiotics are recommended in the perioperative period.

The instrumentation is illustrated and explained in the Appendix.

Initial equipment and supplies needed for diagnostic arthroscopy:

- *Skin marking pen*
- *Ruler for drawing straight lines*
- *Scalpel*
- *Arthroscope sheath and trocar with sharp obturator for creation of the working space / for access to the site of surgery*
- *Prepared irrigation liquid*

3.3 Arthroscopic Approach to the Temporomandibular Joint

The TMJ is approached through two trocars (ports), each 2 mm in diameter. The HOPKINS® telescope (arthroscope) is introduced through one of the two trocars, which also serves as an irrigation port. The irrigation liquid is drained through the second trocar, which also provides access for passing instruments to the operative site.

Technique of TMJ Puncture for Diagnostic Arthroscopy:
After the TMJ region has been palpated and inspected and the position of the condylar head has been determined by passive movement of the TMJ, the trocar sites are marked using the method described by *Blaustain* and *Heffez* (1990) and *Reich* (1995).

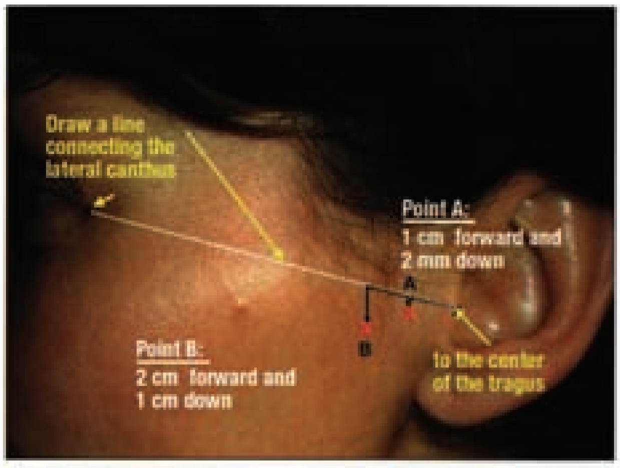


Fig. 3
Planning the trocar sites for TMJ arthroscopy.

1. Locate and mark the center of the tragus.
2. Locate and mark the lateral canthus of the eye.
3. Draw a straight line between the center of the tragus and the lateral canthus.
4. Measure and mark a point on the line that is 10 mm from the center of the tragus, and mark a point (**A**) located 2 mm below it. The trocar with obturator will be inserted at that point, and the obturator will be removed for insertion of the arthroscope.
5. Measure and mark a point on the original line that is 20 mm from the center of the tragus. Drop a perpendicular at that point, measure 10 mm down from the line, and mark that point (**B**). That is the site where the trocar with sharp obturator will be introduced (**Fig. 3**).

Before inserting the trocars, we palpate the TMJ region and move the joint to confirm that the points have been marked correctly, since some distortion may occur due to shifting of the skin.

Puncturing the Joint:
At **point A** (**Fig. 3**): Insert the sharp obturator/trocar assembly to the temporal bone, angling it medially upward. While keeping the obturator tip in contact with the bone, advance it approximately 2.5 cm into the upper joint space, then remove the obturator.
Check the correct placement of the trocar in the joint space by infusing irrigation fluid through the arthroscope sheath (trocar) and passively opening and closing the mandible. If the fluid level in the arthroscope sheath moves with the jaw, this confirms that the trocar is safely in the joint space. Now introduce the arthroscope with attached video camera (remember to perform the white balance!) into the sheath, and connect the irrigation line to the arthroscope sheath.

At **point B** (**Fig. 3**): Insert the second sharp obturator at point B with the tip of the obturator angled upward. Direct it toward the tip of the arthroscope trocar and advance it until it is in contact the temporal bone of the glenoid fossa. Keeping the obturator tip in contact with the bone, advance it approximately 2.5 cm into the upper joint space, then remove the obturator.
Check the correct placement of the arthroscope sheath in the joint space by infusing irrigation fluid through the access port and passively opening and closing the mandible. The fluid level in the arthroscope sheath should move with the jaw, confirming that the sheath is correctly positioned in the joint space.

Next open the inflow stopcock on the arthroscope sheath, which is connected to an infusion system. If continuous irrigation is obtained with an inflow pressure of approximately 1000 mm H_2O and there is a good reflux of irrigation liquid through the sheath, an infusion extension tubing can be connected to the arthroscope sheath (to direct the fluid to a collection vessel), and diagnostic arthroscopy may begin.
The outflowing fluid is collected in the vessel and may be discarded or be retained for diagnostic testing. After the operating room lights are turned off, the surgeon proceeds with indirect diagnostic TMJ arthroscopy while watching the video monitor.
Another technique for puncturing the upper joint space is to use a blunt obturator after filling the upper compartment with fluid injected through a hypodermic needle. To avoid injuring the disc and retrodiscal tissue, we track the sharp point along the bone of the glenoid fossa, working our way around the lateral rim of the fossa until we feel the point "fall" into the joint space. Histologic studies in animal models show that a fine scratch in the bone of the lateral glenoid rim will heal completely with no adverse sequelae for the joint. Since distending the joint space with fluid may sometimes result in a faulty puncture, an alternative method is to pull the lower jaw forward and downward to open up the joint space.

3.4 Instrument Use, Description of Findings, and Documentation

First the video camera is rotated to a horizontal position on the arthroscope to ensure proper horizontal alignment of the arthroscopic image.
When a 30°-HOPKINS® forward-oblique telescope is used, the viewing angle can be adjusted by rotating the scope beneath the camera head. The advantage of using a 30° scope is that it provides a larger viewing angle, making it possible to visualize more of the joint. Care is taken to keep the camera aligned in the horizontal plane. Because working with a 30° scope is somewhat more complicated than working with a 0°-straight-ahead scope, we recommend starting with the 0° scope, which usually gives a satisfactory view (**Figs. 4a, b**).
Anterior-posterior orientation is checked by passively opening and closing the jaw. When the mouth opens, the disc moves anteriorly and the retrodiscal tissue becomes more tense.

Fig. 4a, b
After introducing the arthroscope, the surgeon establishes orientation in the TMJ by watching the video monitor while manually opening the patient's mouth.

If a "red-out" occurs during arthroscopy (**Fig. 5**), this means that there is too much blood in the irrigating fluid due to insufficient flow through the joint. The remedy is to check and adjust the fluid inflow and outflow so that adequate joint irrigation is maintained by the system inflow pressure alone. When this has been accomplished, the field should clear and the intra-articular structures should reappear in the image.

At most institutions, the classification of TMJ disc displacements has been based on clinical findings such as incisal edge clearance and the degree of displacement shown by magnetic resonance imaging.

However, experience in surgical patient groups has shown that the preoperative classification often does not correlate with the arthroscopic findings and the pattern of complaints. It seems preferable, therefore, to classify disc displacements on the basis of arthroscopic findings.

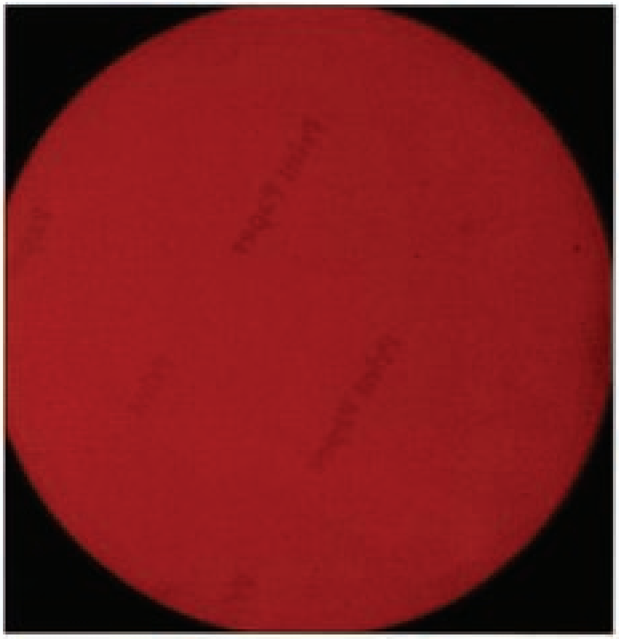


Fig. 5
Arthroscopic "red-out" due to insufficient lavage

The following points should be noted:

1. Landmarks are needed for recognizing and classifying disc displacement.
2. It should be possible to define and evaluate the landmarks simultaneously in the same arthroscopic field.
3. For taking measurements, it would be helpful to project a scale or grid into the arthroscopic image that relates directly or indirectly to actual dimensions.
4. Mouth opening should be taken into account, since the displacement depends on the degree of mouth opening. For reproducibility, disc position should always be determined at equal degrees of incisal edge clearance.

Two useful landmarks are the usually well-defined junction between the disc and retrodiscal tissue and the most caudal (lowest) point of the articular tubercle.

It is not always possible to define both landmarks simultaneously in the arthroscopic field. But nonvisualization of the junction between the disc and retrodiscal tissue can itself be used as a classification criterion (see below). Based on my research of the literature, the problem of projecting a measurement scale into the arthroscopic image has not yet been solved, and so the arthroscopic classification of disc displacement continues to be a subjective assessment that is not entirely reproducible. Surgical navigation may be the key to eliminating the subjective factor (see Chapter 4.5). The most reproducible way to take into account mouth opening is by classifying the disc displacement in the closed-mouth and maximum open-mouth positions.

Arthroscopy can be used to stage the morphological changes in the TMJ. This is helpful both in making a prognosis and in selecting patients for further treatment.

Arthroscopic staging is based on the degree of disc displacement and the degree of changes in the retrodiscal tissue in relation to the articular tubercle.

As explained below, we classify anterior disc displacements into three stages, each of which has associated therapeutic and prognostic implications.

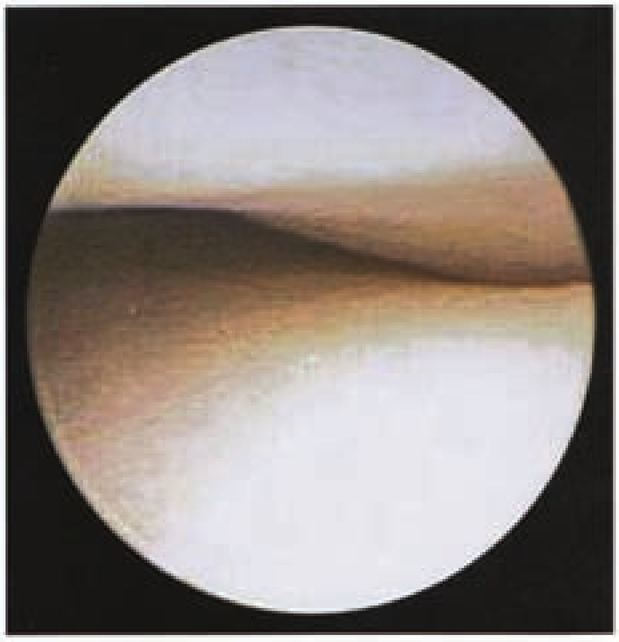
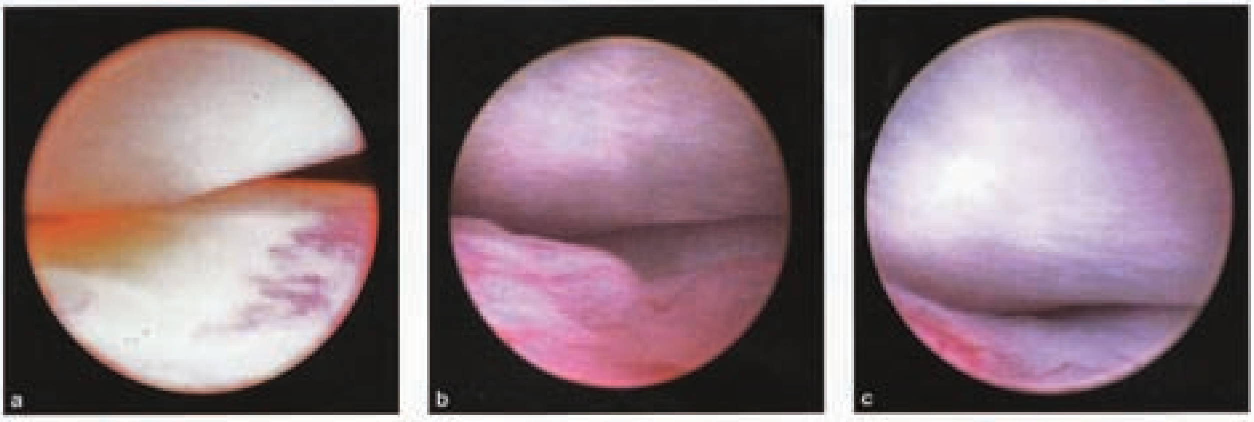


Fig. 6
Arthroscopic view of a **stage I** disc displacement.
Left and center: view of the articular tubercle and underlying disc.
Right: view of the hyperplastic retrodiscal tissue.

Classification of disc and retrodiscal changes by TMJ arthroscopy, taking into account the degree of mouth opening (closed-mouth and maximum open-mouth positions):

Stage I anterior disc displacement (**Fig. 6**): The disc shows a slight degree of anterior displacement (with reduction) when the mouth is closed. At maximum mouth opening the disc is still below the tubercle, and there is little if any limitation of disc gliding (and thus of mouth opening). The retrodiscal tissue is elongated and its function is impaired (see also **Fig. 9a**).
As **Fig. 6** illustrates, the two most important regions for evaluating TMJ disease (the retrodiscal region and disc-tubercle region) cannot always be seen in the same image due to the 1.9-mm diameter of the arthroscope. In this case the regions must be evaluated separately and are then correlated to interpret the images.

Stage II anterior disc displacement (**Fig. 7**): Only a small, posterior portion of the disc is still below the tubercle at maximum mouth opening, and there is significant limitation of disc gliding (and mouth opening). The retrodiscal tissue is moderately elongated and its function is impaired.



Figs. 7a–c
Arthroscopic view of a **stage II** disc displacement. The junction of the disc and retrodiscal tissue is below the tubercle; normally it should lie farther back in the joint.

Stage III anterior disc displacement (Fig. 8): The disc is anterior to the tubercle when the mouth is maximally opened, and there is a complete or almost complete limitation of disc gliding (and mouth opening). The retrodiscal tissue is markedly elongated, and its function is profoundly impaired.

Figure 9a shows various degrees of retrodiscal tissue changes that correlate with the three stages of anterior disc displacement. The stages of disc displacement illustrated by the arthroscopic images in Figs. 6-8 are shown schematically in **Fig. 9b**.

The arthroscopic images should be documented on videotape, video printouts, or digital media for permanent archiving. If desired, the images may be written onto a CD for viewing by the patient or the next attending physician.

Stage I and stage II disc displacements are indications for arthroscopic shortening of the retrodiscal tissue, with a good long-term prognosis. Stage III displacement can be treated arthroscopically with a guarded long-term prognosis, and poor responders can be referred for further surgical treatment.

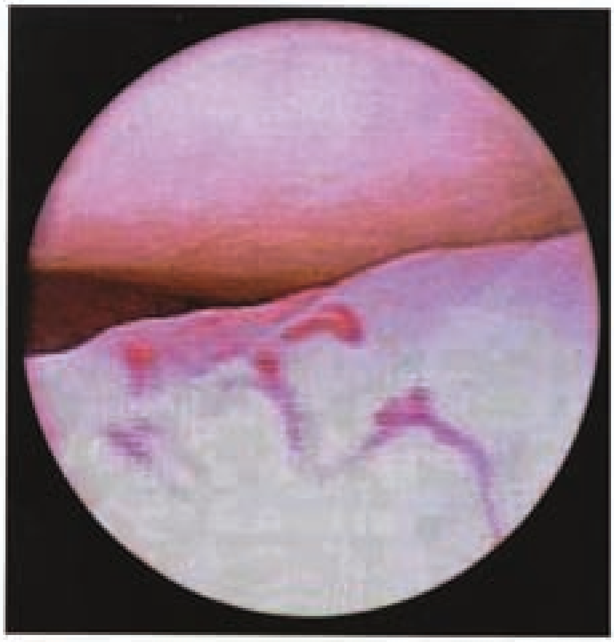


Fig. 8
Arthroscopic view of a stage III disc displacement. The elongated retrodiscal tissue is below the tubercle, and the disc lies anterior to the condylar head and tubercle.

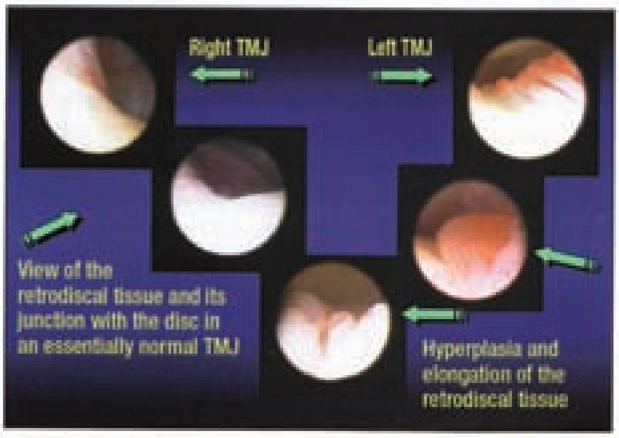


Fig. 9a
Arthroscopic appearance of the retrodiscal tissue and medial articular surface at various stages of disc displacement and associated hyperplasia and elongation of the retrodiscal tissue.

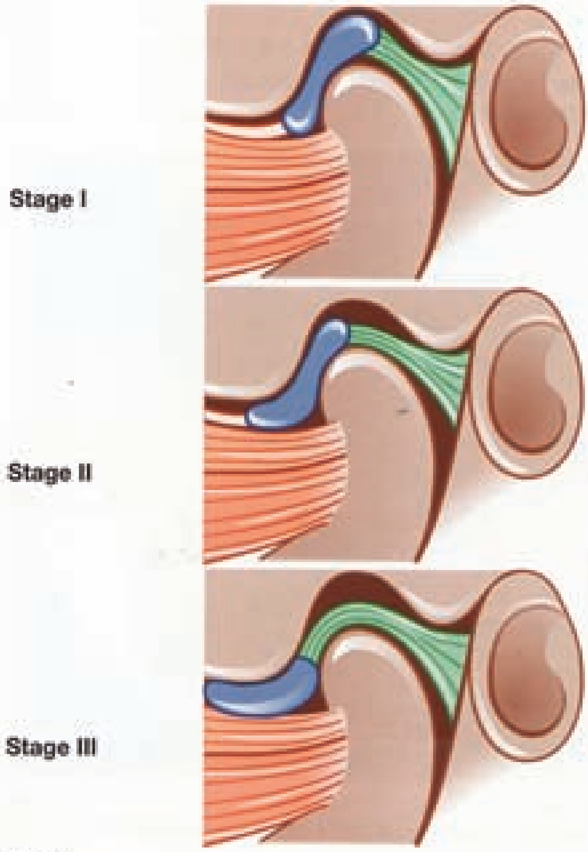


Fig. 9b
Schematic representation of the stages of anterior disc displacement.

4.0 Minimally Invasive Arthroscopic Treatment of Disk Displacement and Elongation of the Retrodiscal Tissue Combined with Diagnostic Arthroscopy

4.1 Shortening the Retrodiscal Tissue with a Water-Jet Scalpel

TMJ disorders are becoming an increasingly widespread problem in our society. The most common disorders involve an elongation of the retrodiscal tissue combined with anterior disc displacement. Surgical treatment is indicated for particularly severe cases that have not been adequately managed by conservative therapy.

The primary goal of surgical treatment is to improve the function of the retrodiscal ligaments and prevent functionally significant disc displacement.

In an open surgical approach, this is accomplished by excising a portion of the retrodiscal tissue and reapproximating it with sutures to "tie back" the disc. It is desirable to correct the retrodiscal tissue and reduce the articular disc by means of a minimally invasive arthroscopic procedure. Scarring can be induced in the TMJ endoscopically by creating a surgical wound in the retrodiscal tissue. This led to the idea of using a water-jet scalpel arthroscopically to shorten the retrodiscal tissue.

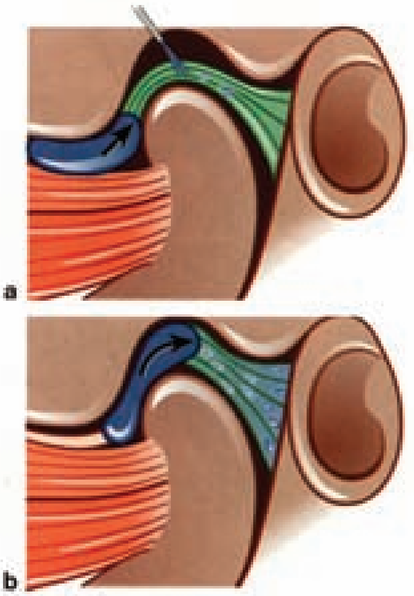


Fig. 10a, b
Shortening the retrodiscal tissue with a water-jet scalpel:
a Locating the retrodiscal tissue,
b Appearance after treatment with the water-jet scalpel. The water jet causes the retrodiscal tissue to swell, producing an immediate shortening effect. This effect is perpetuated by subsequent scarring of the tissue.

The rationale of this procedure is to shorten and tighten the posterior ligaments as a means of returning the articular disc to its original anatomical position (*Kaduk* et al. 2005).

While a simple diagnostic arthroscopy without tissue sampling requires only an arthroscope port and a fluid drainage port, retrodiscal surgery additionally requires that a port for operating instruments be placed precisely at the operative site in the TMJ. This **triangulation technique** has a relatively high degree of technical difficulty and takes a considerable amount of practice to learn. In triangulation, the tip of the arthroscope port is placed in the upper joint space so that the working space can be created under arthroscopic guidance via the video monitor. The best point in the retrodiscal tissue for treatment with the water-jet scalpel is the junction between its anterior and middle thirds. When the arthroscope sheath has been placed, the water-jet scalpel is introduced into the operating channel, and that portion of the retrodiscal tissue is treated from medial to lateral at a pressure of 60 bar (**Fig. 10**). Next the function of the disc and retrodiscal tissue is checked arthroscopically at rest and during passive movement of the lower jaw.

Owing to the excellent biocompatibility of the cutting medium (water), the low degree of tissue necrosis, and the excellent control of the water-jet cutting intensity, which is continuously adjustable from 1 to 150 bar, we prefer the water-jet scalpel marketed by Erbe Elektromedizin, Tübingen, Germany. Another advantage of the variable jet intensity is the ability to apply selective pressure treatment to pain receptors in the retrodiscal tissue (similar to acupressure). If the dominant symptom is pain, the water-jet treatment will at least interrupt the vicious cycle and improve the patient's complaints.

4.2 Aftercare and Complications of Water-Jet Treatment

Key issues following arthroscopy are the correct assessment of findings and the decision-making for further management.

We recommend postoperative immobilization with a head-and-chin dressing for 2 days, a soft diet for 2 weeks, no excessive mouth opening or stresses for 4 weeks, and continued supportive management with splints and physical therapy. Subsequent treatment depends on the course or progression of the disorder (see our treatment protocol for anterior disc displacement in Chapter 2).

Postoperative swelling about the TMJ occasionally leads to obstruction of the Eustachian tube accompanied by transitory hearing impairment.

Pressure on the posterior trocar may cause it to bend backward and damage the external auditory canal. Very rarely, this may cause fractures and fine cracks in the ear canal, similar to those occasionally seen in association with subcapital fractures of the mandibular condyle. These injuries are treated with an antibiotic-impregnated ointment packing until they are completely healed.

Other complications of arthroscopic surgery have been reported in the literature, but so far we have not encountered them at our institution: penetration of the middle cranial fossa, cerebral injuries, and injuries to the middle ear, inner ear, or facial nerve. All of these potential complications and problems should be disclosed to the patient during the informed consent discussion.

4.3 Other Arthroscopic Treatment Options (Nd:YAG and Holmium:YAG Lasers, Electrosurgery)

Some authors (*Mosby* 1993, *Murakami* et al. 1996) state that arthroscopic irrigation alone can produce a permanent therapeutic effect in properly selected patients. Pain relief in these cases is often associated with improved clinical findings such as increased mouth opening, decreased crepitus, or both.

The goal of arthroscopic surgical treatment is to augment or achieve this effect through specific measures in the TMJ.

Besides the water-jet scalpel, a Nd: YAG or holmium: YAG laser can be used to induce scarring and shortening of the retrodiscal tissue (**Fig. 11**). The laser energy is delivered directly to the retrodiscal tissue through an optical fiber passed through the working channel into the TMJ. A similar technique is used with electrosurgical cutting and cautery instruments.

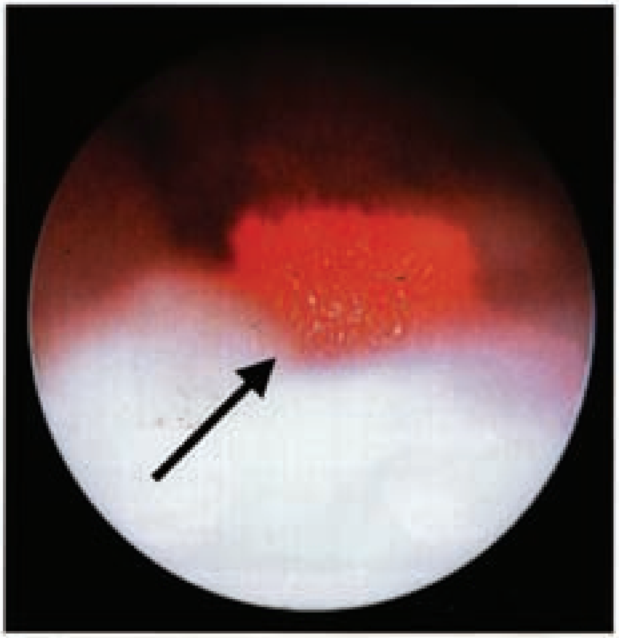
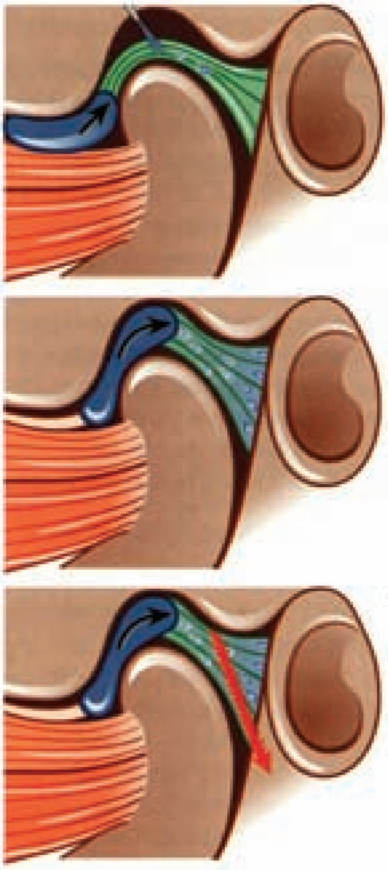


Fig. 11
Use of the Nd:YAG laser (arrow) in the TMJ.



a b c

Figs. 12a–c
Shortening the retrodiscal tissue with a polylactide screw.
(**a, b**): Treatment with the water-jet scalpel. (**c**): Polylactide screw insertion in the preauricular connective tissue.

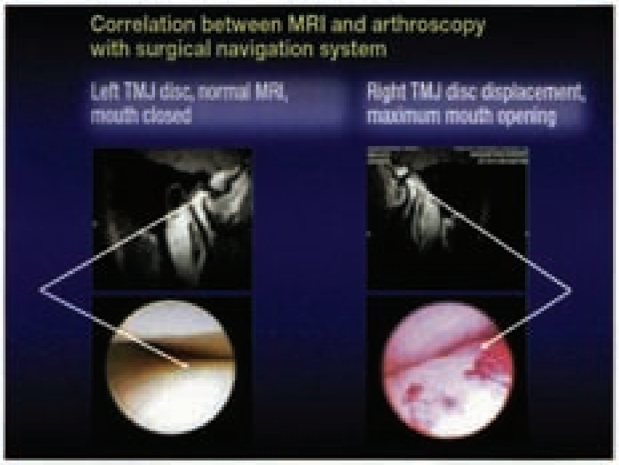


Fig. 13
Correlation between MRI and arthroscopy with a surgical navigation system.

4.4 Arthroscopic Fixation Techniques – An Additional Therapeutic Option

If the water-jet treatment alone is insufficient, the retrodiscal tissue can be fixed with an absorbable polylactide screw as another alternative to open surgery (**Fig. 12**). Generally, however, we allow approximately 1 year for the water-jet scar to mature before concluding that it has been unsuccessful and further treatment is needed. Based on our studies in the porcine TMJ, the polylactide screw induces considerably more scarring in the retrodiscal tissue than the water-jet scalpel alone, without causing other clinically significant side effects (*Kaduk* et al. 2002). This technique should be reserved for experienced TMJ surgeons, and rigorous patient selection criteria should be applied. Similar techniques are used for arthroscopic surgery of the knee ligaments and menisci, for example.

4.5 TMJ Arthroscopy and Surgical Navigation

At present there are three reasons why a surgical navigation system could contribute to the improvement of arthroscopic surgical technique:

1. It allows a more objective arthroscopic diagnosis and improves the correlation between MRI and arthroscopic findings.
2. It simplifies the triangulation technique (see Chapter 4.1).
3. It can direct the insertion of polylactide screws and other arthroscopic fixation devices.

The successful use of a navigation system depends critically on the precision of preoperative imaging and on a precise registration of the patient with navigation software, which currently has an accuracy of ± 2 mm.

5.0 Arthroscopic Training in an Animal Model

In the past, human cadaver studies and visiting physician programs were the only means available for learning arthroscopic surgery in patients. But practice in human cadavers is of limited value due to postmortem tissue changes, which are present even in unfixed specimens. There is little or no opportunity for interpreting arthroscopic findings, evaluating tissue blood flow, or differentiating between normal findings and pathologic changes.

Visiting physician programs are also limited in their ability to provide adequate operating room experience. It is difficult to justify the time-consuming practicing of triangulation techniques and instrument manipulations in actual patients.

I have found that practice in an animal model is essential for acquiring independent arthroscopic operating experience without running the risk of a higher complication rate. Through repeated practice in such a model, the operator will learn to use the arthroscope so proficiently that he or she can ultimately perform successful arthroscopic surgery in human patients.

A model is also an indispensable tool for the advancement of arthroscopic operating techniques.

In our search for a suitable model for TMJ arthroscopy, we were able to develop a technique in the porcine jaw (*Kaduk* et al. 2003). We have found that arthroscopic images of the human and porcine TMJ are visually indistinguishable from each other, indicating that this species is an excellent model for arthroscopic exercises and examinations in the TMJ. The only difference between the human and porcine TMJ is the location of the access ports. Once the upper joint space has been entered, there are no appreciable differences between the human TMJ and our animal model. **Figure 14** shows the placement of the trocar sites about the porcine TMJ. All further steps in diagnostic arthroscopy and arthroscopic surgery of the retrodiscal tissue are the same as previously described (see Chapter 3).

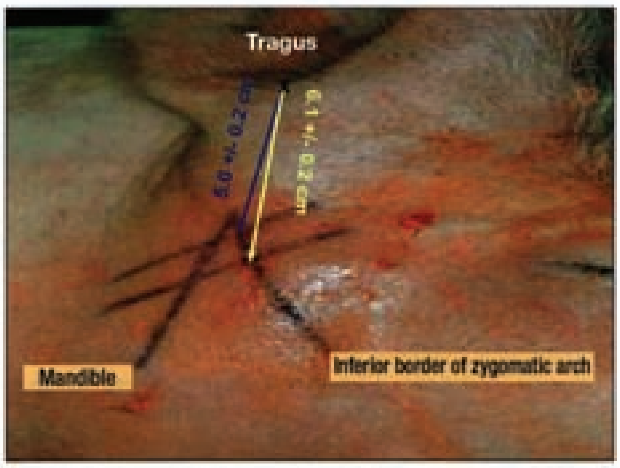


Fig. 14
Arthroscopic approach to the porcine TMJ (trocar sites have been marked on the skin).

6.0 Concluding Remarks

Practice operations in the animal model have yielded the important discovery that beginners in particular must exercise a great deal of patience when locating and placing the arthroscope sheath (triangulation technique) in order to achieve the goal of the arthroscopic procedure. A second important insight is the importance of staying in contact with the bone of the glenoid fossa when entering the upper joint space. We have found that when these precautions are ignored, the triangulation invariably fails. This can lead to disc perforations and retrodiscal injuries that are extremely difficult to repair. When work in patients is deferred until the operator has gained adequate experience with TMJ arthroscopy in the animal model, the complication rate is correspondingly low.

Since neither cadaver training nor visiting physician programs can provide adequate experience, we supplement arthroscopic training in the porcine TMJ with the study of human TMJ specimens in order to close this gap both for clinicians in training and for clinical researchers.

This course of training may then be followed by a visiting physician program and independent clinical work. We recommend that visiting physicians do their rotation individually with personal supervision rather than in groups. When arthroscopic shortening of the retrodiscal tissue with a water-jet scalpel (see Chapter 4.1) becomes an established technique, it will be possible to select patients for surgical treatment at a considerably earlier stage.

Another aspect is that the traditional policy of restraint based on concerns about the risks of open TMJ surgery need no longer prevail until the distress experienced by patients justifies the higher complication rate of open surgery.

7.0 Recommended Reading

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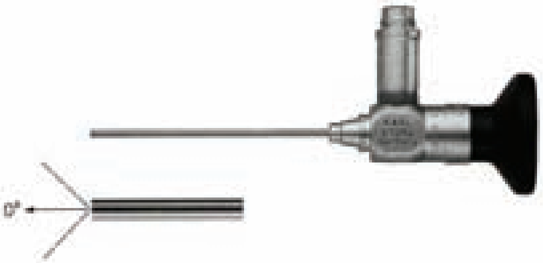
Basic Set for Arthroscopy of the Temporomandibular Joint, consisting of:

58705 AA	HOPKINS® **Straight Forward Telescope 0°,** diameter 1.9 mm, length 6.5 cm, **autoclavable,** fiber optic light transmission incorporated, color code: green
58706 AN	**High Flow Arthroscope Sheath,** diameter 2.5 mm, working length 4 cm, for use with HOPKINS® Telescope 0°, 58705 AA, color code: green
58705 BA	HOPKINS® **Forward-Oblique Telescope 30°,** diameter 1.9 mm, length 6.5 cm, **autoclavable,** fiber optic light transmission incorporated, color code: red
58706 BN	**High Flow Arthroscope Sheath,** diameter 2.5 mm, working length 4 cm, for use with HOPKINS® Telescope 30°, 58705 BA, color code: red
58706 BS	**Obturator,** sharp, for use with Arthroscope Sheaths 58706 AN/BN
58706 BT	**Obturator,** blunt, for use with Arthroscope Sheaths 58706 AN/BN
58717 X	**Trocar,** diameter 1.8 mm, length 4 cm, for use with 58717 XB/XS
58717 XS	**Obturator,** sharp, for use with Trocar 58717 X
58717 XB	**Obturator,** blunt, for use with Trocar 58717 X
58717 PZ	**Biopsy Forceps,** single-action jaws, diameter 1.3 mm, length 6 cm
58702 EO	**Scissors,** upbiting, diameter 2 mm, working length 10 cm
58702 EK	**Scissors,** downbiting, diameter 2 mm, working length 10 cm
58702 DH	**Forceps,** through-cutting, diameter 2 mm, working length 10 cm
58702 U	**Grasping Forceps,** diameter 2 mm, working length 10 cm
58702 M	**Knife,** bayonet-shaped, diameter 1.5 mm, working length 7.5 cm
58702 N	**Sickle Knife,** diameter 1.5 mm, working length 7.5 cm
58702 S	**Palpation Hook,** graduated, diameter 1.5 mm, length of hook 1 mm, working length 7.5 cm
58702 W	**Changing Rod,** for sheaths and trocars, length 15 cm
58702 X	**Trocar,** diameter 2.5 mm, length 3.5 cm, for use with instruments 58702 M/N/S
58702 XS	**Obturator,** sharp, for use with Trocar 58702 X
58702 XT	**Obturator,** blunt, for use with Trocar 58702 X

Basic Set for Arthroscopy of the Temporomandibular Joint

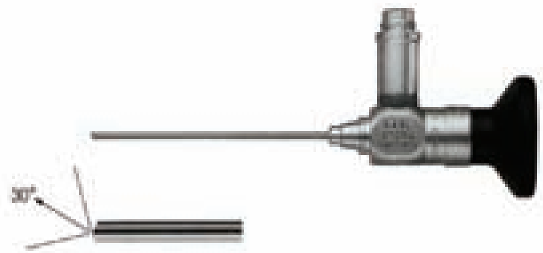


58705 AA **HOPKINS® Straight Forward Telescope 0°,**
diameter 1.9 mm, length 6.5 cm,
autoclavable,
fiber optic light transmission incorporated,
color code: green

58706 AN **High Flow Arthroscope Sheath,**
diameter 2.5 mm, working length 4 cm,
for use with HOPKINS® Telescope 0°,
58705 AA, color code: green

58706 BS **Obturator,** sharp, for use with Arthroscope Sheaths 58706 AN/BN

58706 BT **Obturator,** blunt, for use with Arthroscope Sheaths 58706 AN/BN



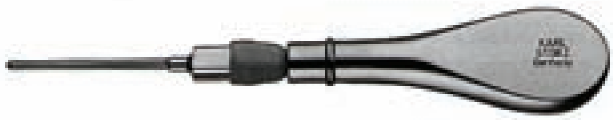
58705 BA **HOPKINS® Forward-Oblique Telescope 30°,**
diameter 1.9 mm, length 6.5 cm,
autoclavable,
fiber optic light transmission incorporated,
color code: red

58706 BN **High Flow Arthroscope Sheath,**
diameter 2.5 mm, working length 4 cm,
for use with HOPKINS® Telescope 30°,
58705 BA, color code: red

58706 BS **Obturator,** sharp, for use with Arthroscope Sheaths 58706 AN/BN

58706 BT **Obturator,** blunt, for use with Arthroscope Sheaths 58706 AN/BN

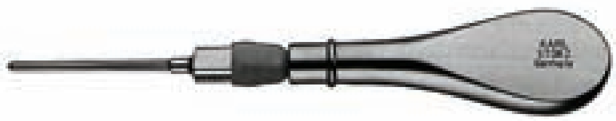
Basic Set for Arthroscopy of the Temporomandibular Joint



58717 X **Trocar,** diameter 1.8 mm, length 4 cm, for use with 58717 XB/XS

58717 XS **Obturator,** sharp, for use with Trocar 58717 X

58717 XB **Obturator,** blunt, for use with Trocar 58717 X



58702 X **Trocar,** diameter 2.5 mm, length 3.5 cm, for use with instruments 58702 M/N/S

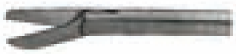
58702 XS **Obturator,** sharp, for use with trocar 58702 X

58702 XT **Obturator,** blunt, for use with trocar 58702 X

Basic Set for Arthroscopy of the Temporomandibular Joint

58717 PZ

58702 EO **Scissors,** upbiting, diameter 2 mm, working length 10 cm



58702 EK **Scissors,** downbiting, diameter 2 mm, working length 10 cm

58702 DH **Forceps,** through-cutting, diameter 2 mm, working length 10 cm

58702 U **Grasping Forceps,** diameter 2 mm, working length 10 cm

58717 PZ **Biopsy Forceps,** single-action jaws, diameter 1.3 mm, length 6 cm

58702 N **Sickle Knife,** diameter 1.5 mm, working length 7.5 cm

58702 M **Knife,** bayonet-shaped, diameter 1.5 mm, working length 7.5 cm

58702 S **Palpation Hook,** graduated, diameter 1.5 mm, length of hook 1 mm, working length 7.5 cm

58702 W **Changing Rod,** for sheaths and trocars, length 15 cm

IMAGE1™ HD hub *NEW*

HD hub Camera Control Unit

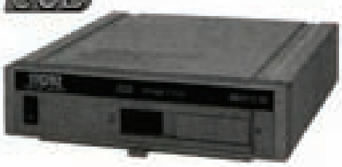
IMAGE 1 HD

- **Genuine FULL HD (High Definition) is guaranteed by a maximum resolution and the consistent use of the native 16:9 aspect ratio throughout the entire image chain, from image capture, signal transmission to display**
- **HD-compatible endoscopic video camera systems must be equipped with a CCD chip supporting the 16:9 input format and require that image capture is performed at a resolution of 1920 x 1080 pixels**

The benefits of FULL HD (High Definition) for medical applications are:

- **5 times higher input resolution of the camera delivers more detail and depth of focus**
- **Using 16:9 format during image acquisition enlarges the field of view**
- **The 16:9/16:10 format of the widescreen monitor supports ergonomic viewing**
- **Enhanced color brilliance for optimal diagnosis**
- **Progressive scan technology provides a steady, flicker-free display and helps eliminate eyestrain and fatigue**

SCB®



22 2010 11U102

22 2010 11U102 **IMAGE1™ HD hub Camera Control Unit** (CCU)

for use with IMAGE1™ HD and standard one- and three-chip camera heads, max. resolution 1920 x 1080 pixels, with integrated **KARL STORZ-SCB®** and integrated Image Processing Module, color system **PAL/NTSC,** power supply 100 – 240 VAC, 50/60 Hz

consisting of:

22 2010 20U102	**IMAGE1™ HD hub (with SDI) Camera Control Unit**
400 A	**Mains Cord**
400 B	**Mains Cord, US-version**
3 x 536 MK	**BNC/BNC Video Cable,** length 180 cm
547 S	**S-Video (Y/C) Connecting Cable,** length 180 cm
20 2032 70	**Special RGB Connecting Cable**
2x **20** 2210 70	**Connecting Cable,** for controlling peripheral units, length 180 cm
20 0400 86	**DVI Connecting Cable,** length 180 cm
20 0901 70	**SCB Connecting Cable,** length 100 cm
20 2002 31U	**Keyboard,** with English character set

Specifications:

Signal-to-noise ratio	AGC	Video output	Input
IMAGE1™ Three-chip camera systems ≥ 60 dB	Microprocessor-controlled	- Composite signal to BNC socket - S-Video signal to 4-pin Mini DIN socket (2x) - RGB signal to D-Sub socket - DV signal to DV socket (only IMAGE1™ with DV module) - SDI signal to BNC socket (only IMAGE1™ with SDI module) (2x) - HD signal to DVI-D socket (2x)	Keyboard for title generator, 5-pin DIN socket

Control output /input	Dimensions w x h x d (mm)	Weight (kg)	Power supply	Certified to:
- KARL STORZ-SCB® at 6-pin Mini DIN socket (2x) - 3.5 mm stereo jack plug (ACC 1, ACC 2), - Serial port at RJ-11	305 x 89 x 335	2.95	100-240 VAC, 50/60 Hz	IEC 601-1, 601-2-18, CSA 22.2 No. 601, UL 2601-1 and CE acc. to MDD, protection class 1/CF

IMAGE1™ HD *NEW*

HD Camera Head

22 2200 50-3/**22** 2201 50-3

22 2200 50-3	**50 Hz**	**IMAGE1™ H3, Three-Chip HD Camera Head**

max. resolution 1920 x 1080 pixel, Progressive Scan, 50 Hz,
with 2 freely programmable Camera Head buttons,
with integrated Parfocal-Zoom focal length f = 14 – 30 mm (2x),
for use with color system **PAL**

22 220150-3	**60 Hz**	**IMAGE1™ H3, Three-Chip HD Camera Head**

max. resolution 1920 x 1080 pixel, Progressive Scan, 60 Hz,
with 2 freely programmable Camera Head buttons,
with integrated Parfocal-Zoom focal length f = 14 – 30 mm (2x),
for use with color system **NTSC**

Specifications:

IMAGE1™ HD Camera Heads	**H3**
50 Hz	**22** 2200 50-3
60 Hz	**22** 2201 50-3
Image sensor	3x ¼" CCD chip
Pixels output signal (H x V)	1920 x 1080
Resolution (pixels)	1920 x 1080
Dimensions	Diameter 31-48 mm, length 114 mm
Weight	210 g
Min. sensitivity	F1.4/1.9 lux
Lens	Integrated Parfocal Zoom Lens, f = 14-28 mm

Standard IMAGE1™ camera heads may also be connected to IMAGE1™ HD hub camera control unit (CCU).

IMAGE1™ HD *NEW*

HD Flat Screen

KARL STORZ HD Flat Screens Color systems PAL/NTSC	Version	Order No.	Screen diagonal	Max. screen resolution	Video input						
			58.5 cm (23")	1920 x 1200	Composite signal to BNC socket	S-Video to 4-pin Mini DIN socket	RGB to 5x BNC socket	VGA to 15-pin HD-D-Sub socket	SDI to BNC socket	HD-SDI to BNC socket	DVI to DVI-D socket
	Wall mounted with VESA 100-adaption	9523 NB	•	•	•	•	•	•	•	•	•
	Desktop with pedestal	9523 N									

9523 NB **23" KARL STORZ HD Flat Screen**
image format 16:10, wall-mounted with VESA 100-adaption, color systems **PAL/NTSC,** max. screen resolution 1920 x 1200, video inputs: composite, S-Video, RGB, VGA, SDI, and DVI, brightness 500 cd/m², contrast ratio 700:1, power supply 100 – 240 VAC, 50/60 Hz
consisting of:
9523 NG **23" HD Flat Screen**
9523 PS **External 24 VDC Power Supply**
400 A **Mains Cord**

9523 N **23" KARL STORZ HD Flat Screen**
image format 16:10, desktop with pedestal, color systems **PAL/NTSC,** max. screen resolution 1920 x 1200, video inputs: composite, S-Video, RGB, VGA, SDI, and DV brightness 500 cd/m², contrast ratio 700:1, power supply 100 – 240 VAC, 50/60 Hz
consisting of:
9523 NG **23" HD Flat Screen**
9523 PS **External 24VDC Power Supply**
400 A **Mains Cord**
9419 NSF **Pedestal**

Specifications:

Brightness	Max. viewing angle	Video input	Pixel distance	Contrast ratio	Input signal level
500 cd/m²	178° vertical	- Composite signal to BNC socket - S-Video signal to 4-pin Mini DIN socket - RGB signal to 5 x BNC sockets - SDI signal to BNC socket - HD-SDI signal to BNC socket - DVI signal to DVI-D socket	0.258 mm	700:1	0.7 Vpp

Rated power	Operating conditions	Storage	Relative humidity	Dimensions in w x h x d (mm)	Power supply	Certified to:
80 Watt	0-40 °C	-20-60 °C	5-85 %, non-condensing	546 x 366 x 98	100-240 VAC	EN 60601-1, protection class IPX 1

Accessories for Video Documentation

495 NL **Fiber Optic Light Cable,**
diameter 3.5 mm, length 180 cm

495 NA **Same,** length 230 cm

Cold Light Fountain XENON 300 SCB®

20133101-1 **Cold Light Fountain XENON 300 SCB®**
with built-in antifog air-pump, and integrated KARL STORZ Communication Bus System SCB®
power supply:
100–125 VAC/220–240 VAC, 50/60 Hz
including:
400 A **Mains Cord**
610 AFT **Silicone Tubing Set,** autoclavable, length 250 cm
20 0901 70 **SCB® Connecting Cord,** length 100 cm

20133027 **Spare Lamp Module XENON**
with heat sink, 300 watt, 15 volt

20133028 **XENON Spare Lamp,** only,
300 watt, 15 volt

Cold Light Fountain XENON NOVA® 300

20134001 **Cold Light Fountain XENON NOVA® 300,**
power supply:
100–125VAC/220–240VAC, 50/60 Hz
including:
400 A **Mains Cord**

20132028 **XENON Spare Lamp,** only,
300 watt, 15 volt

Basic Equipment Cart

29005 LAP **Basic Equipment Cart,**
rides on 4 antistatic dual wheels,
2 equipped with locking brakes,
3 fixed shelfs, one with handles, main switch at vertical beam, integrated cable conduits in vertical beams, drawer unit with lock,
3 horizontal cable conduits, one with cable winding, two with 4-times electrical sub-distributer,
1 set of non-sliding stands for units,
1 TFT-Monitor arm (VESA 75/100),
1 camera holder,
8 power cords (50 cm),
2 equipment rails,
1 CO_2-bottle holder, max. diameter 155 mm, Isolation transformer 230 VAC (50/60 Hz) with 8 sockets and earth potential and earth leakage monitor (2000 VA),

Dimensions: Videocart
730 x 1470 x 716 mm (w x h x d),
shelf: 630 x 480 mm (w x d),
caster diameter: 150 mm

Data Management and Documentation

KARL STORZ AIDA® compact HD

KARL STORZ AIDA® compact HD combines all the required functions for integrated and precise documentation of endoscopic procedures and open surgeries in a single system.

AIDA compact HD:
Voice control

Data Acquisition

AIDA compact HD records still images, video sequences and spoken comments of findings and intraoperative procedures directly from the sterile area. Recordings are activated via touch screen, voice control, footswitch or camera head buttons.

Live display of camera images on the touch screen enables immediate monitoring and selection of the recorded data.

AIDA compact HD:
Review screen

Flexible Review

Before final archiving, the saved data can be viewed or listened to on the review screen. Data no longer required can be simply deleted.

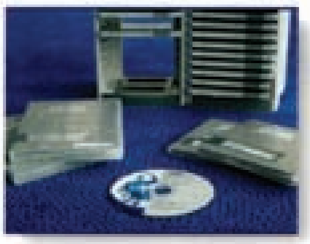
Individual images, video and audio sequences can be renamed and given more meaningful names. A pre-defined selection list with keywords simplifies and speeds up data entry. Furthermore, a comment field is available for entering relevant details of an intervention.

A voice entry of the case report can yet be recorded while viewing video and image files.

AIDA compact HD: *Automatic creation of standard reports*

Efficient data archiving

After a procedure has been completed, KARL STORZ AIDA® compact HD saves all captured data efficiently on DVD, CD-ROM, USB stick, external hard-drive, internal hard-drive and / or network respective on the FTP server. Furthermore the possibility exists to store the data directly on the PACS respective HIS server, over the interface package AIDA communication HL7/DICOM.



AIDA compact HD:
Efficient archiving

Multisession and Multipatient

Efficient data archiving is assured as several treatments can be saved on one DVD, CD-ROM or on an USB stick.

Special features of AIDA compact HD:

- **Digital storage of still images with a resolution of 1920 x 1080, video sequences in 720p and audio files**
- **Interface package DICOM/HL7**
- **Sterile, ergonomic operation via touch screen, voice control, camera head buttons and/or foot switches**
- **Auto detection of the connected camera system on HD-SDI/SD-SDI input (SD-SDI input exclusive with the IMAGE1™ camera system)**
- **Efficient archiving on DVD, CD-ROM or USB stick, multisession and multipatient**
- **Possibility of saving on the network**
- **Optional connection to the PACS, RIS and HIS**
- **Automatic generation of standard reports**
- **Approved use of computers and monitors in the OR environment as per EN 60601-1**
- **Compatibility to the KARL STORZ Communication Bus (SCB) and to the KARL STORZ OR1™ connect series**

➢ **KARL STORZ AIDA® compact HD is an attractive, digital alternative to video printers, video recorders and dictaphones**

20 0406 05U **KARL STORZ AIDA® compact HD System,** documentation system for digital storage of still images, video sequences and audio files **consisting of:**

20 0460 20	**KARL STORZ AIDA control,** with integrated DVD/CD writer
20 0405 77	**AIDA compact II HD Frame Grabber Card**
20 0902 34 U	**PS/2 Compact Keyboard,** English, with cover
20 0404 02-15	**AIDA compact II Software,** with voice control and software protection
20 0402 75	**KARL STORZ USB Stick,** with 1 GB
20 2210 70	**Connecting Cable** (2x)
536 MK	**BNC Connecting Cable,** length 180 cm
536 MKD	**BNC Connecting Cable,** length 30 cm
536 MKE	**BNC Connecting Cable,** length 50 cm
20 0400 86	**DVI Cable,** length 180 cm
400 A	**Mains Cord**
20 0400 87	**Cable MiniDIN-male to BNC-female**

Specifications:

Video Systems	Signal Inputs	Image Formats	Video Formats	Audio Formats	Storage Media
• PAL • NTSC	• S-Video (Y/C) • Composite • DVI-D • HD-SDI, SD-SDI • RGBS	• JPG • BMP	• MPEG2	• WAV	• DVD+R • DVD+RW • DVD-R • DVD-RW • CD-R • CD-RW • USB Stick

KARL STORZ AIDA® DVD-M

Independent "all-in-one" System

Special features:

- **Digital storage of still images, video and audio files (with HD Option storage of still images in FULL HD quality 1920 x 1080)**
- **Digital alternative to video printers, video recorders and dictaphone**
- **Compact design**
- **Simple and intuitive operation**
- **Allows storage on DVD, CD-ROM, USB Stick or Network, multisession and multipatient**
- **HD-DVI (associated with the HD Option), SDI, S-Video (Y/C) and composite input**
- **All video signals are through-patchable to the video monitor**
- **Printing of still images with ink jet printers possible**
- **External touch screen (accessory) confirms to EN 60601-1**
- **Compatible to the KARL STORZ Communication Bus (SCB) and to the OR1™ connect series**

20 2045 01-140 **KARL STORZ AIDA® DVD-M with Smartscreen™,**
color system PAL/NTSC, power supply 100 – 240 VAC, 50/60 Hz,
consisting of:

20 204020-140	**AIDA DVD-M** with integrated DVD/CD recorder and integrated touch screen
400 A	**Mains Cord**
400 B	**Mains Cord,** US version
536 MK	**BNC Connecting Cables,** length 180 cm
547 S	**S-VHS (Y/C) Connecting Cable,** length 180 cm
2x **20** 0400 83	**Adaptor,** BNC-Cinch
20 0400 84	**Serial Interface Cable,** length 20 cm
20 0400 85	**DVI Connecting Cable,** length 20 cm
20 0400 88	**USB Extension Cable,** length 7.5 m

20 2045 20-1 **KARL STORZ AIDA® DVD-M without Smartscreen™,**
color system PAL/NTSC, power supply 100 – 240 VAC, 50/60 Hz,
consisting of:

20 204020-140	**AIDA DVD-M** with integrated DVD/CD recorder
400 A	**Mains Cord**
400 B	**Mains Cord,** US version
536 MK	**BNC Connecting Cables,** length 180 cm
547 S	**S-VHS (Y/C) Connecting Cable,** length 180 cm
2x **20** 0400 83	**Adaptor,** BNC-Cinch
20 0400 88	**USB Extension Cable,** length 7.5 m

20 2000 75 **KARL STORZ AIDA® DVD-M HD Kit Option,**
power supply 100 – 240 VAC, 50/60 Hz,
consisting of:

20 2000 72	**AIDA DVD-M HD Box,** incl. power supply unit and mains cord
20 2000 73	**USB Connecting Cable,** length 180 cm
536 MK	**BNC Connecting Cable,** length 180 cm
20 0400 86	**DVI-D Connecting Cable,** length 180 cm
20 2000 74	**USB Hub**
20 204077-01	**AIDA DVD-M Software Upgrade for HD compatibility**
2x 28003 TE	**Power Cord Adapter**

Drawings:
The schematic anatomical drawings were made by Mrs. **Katja Dalkowski,** M.D.,
Grasweg 42, D-91054 Buckenhof, Germany
Email: kdalkowski@online.de

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Arthroscopy of the Temporomandibular Joint

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