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Teat Endoscopy (Theloscopy) for Diagnosis and Therapy of Milk Flow Disorders in Dairy Cows

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Teat injuries keep occurring, although risk factors and means of prevention [1] are known. Average lactational incidence rates were reported at 2% and 3% [2–13], ranging from 0 to 20% between herds [5,12]. Teat injuries cause economical losses because of treatment costs, decreased milk production [14], and increased risks of mastitis [4,15–18] and premature culling [3,19–27].

Teat injuries may be divided into open and covered injuries. In covered teat injuries, the outer teat skin is unaffected—the injury is located inside the teat [28,29]. Covered teat injuries cause teat stenoses and milk flow disorders [29]. In rural veterinary practice, teat canal stenoses accounted for 80% of all teat stenoses [30]. In slaughtered cows, 70% of all teat alterations were located in the teat canal and Fürstenberg rosette area [31]. In the teat canal area, covered injuries were diagnosed without dislocation (Fig. 1) (50%), with inversion (Fig. 2) (49%) or eversion (1%) of teat canal tissue [32].

This article describes a conservative and a surgical approach to restore milk flow, lower the risk of mastitis, and keep the cow in herd after covered teat injury had occurred. Conservative therapy means resting the teat for 3×3 days. Surgical therapy means diagnosis and minimally invasive therapy by using teat endoscopy (theloscopy). Conservative therapy may be successful in covered teat canal injuries without tissue dislocation. Inversion

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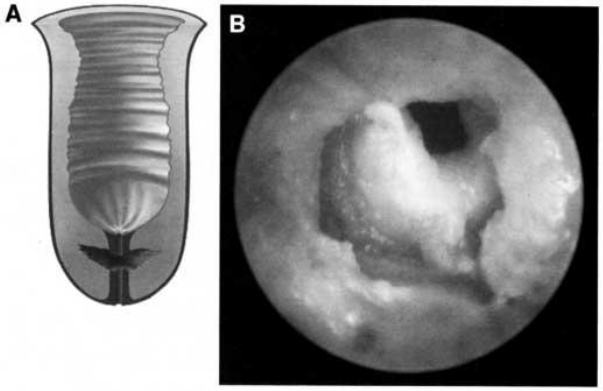

Fig. 1. (*A*) Rupture in the teat canal area (schematic representation). (*B*) Rupture in the teat canal area (canal theloscopy).

of teat canal tissue and other, more complicated injuries require surgery to restore milk flow.

Conservative therapy

Suppose a person hits the tip of his or her finger with a hammer. The finger ends up swollen and black and blue. Would the person treat the finger by massage twice daily and inserting a pipe cleaner into the wound? Or would it be preferable to rest the finger for a couple of days? Conservative therapy means resting and not milking the teat for 3×3 days [33,34]. The sooner the teat is rested, the better. Only teats giving normal milk should be

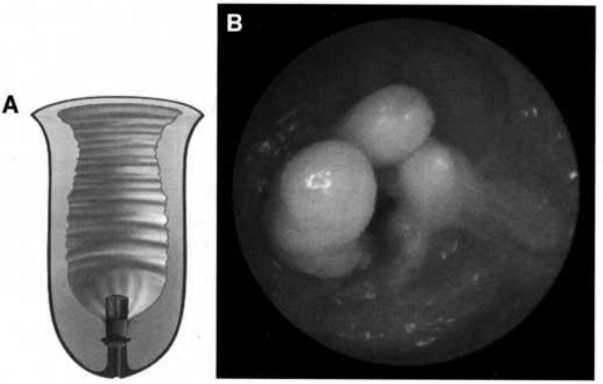

Fig. 2. (*A*) Inversion of teat canal tissue into the teat cistern (schematic representation). (*B*) Three-part inversion of teat canal tissue into the teat cistern (lateral theloscopy).

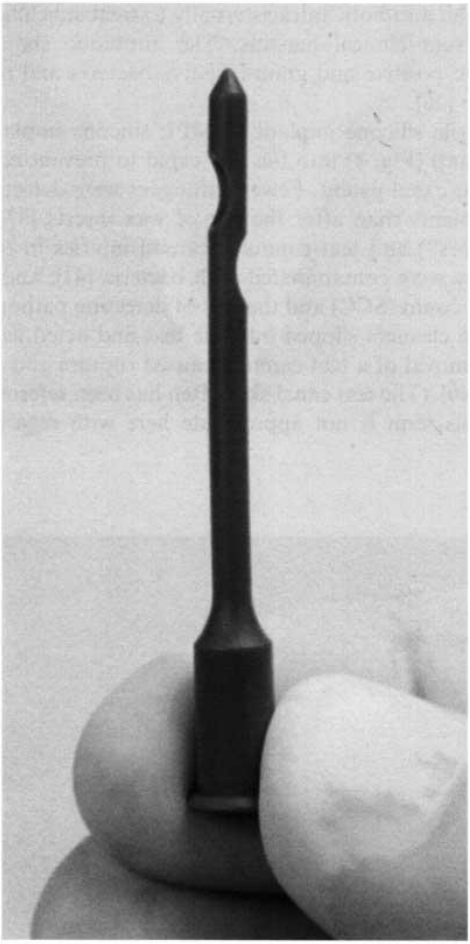

Fig. 3. STERIL—sterile disposable milking tube.

rested. If clinical mastitis is present, the mastitis should be treated first by draining the milk twice daily and administering antibiotics intracisternally. Scrupulous cleanliness is a prerequisite for successful therapy.

Procedure to rest a teat for 3 × 3 days

1. Administer xylazine (0.04 mg/kg) and oxytocin (10 IU) intravenously.
2. Clean the teat with soap and warm water, and disinfect the teat.
3. Drain the milk with a sterile disposable milking tube (eg, STERIL disposable milking tube [www.profs-products.com]) (Fig. 3).

4. Administer an antibiotic intracisternally to treat subclinical mastitis [35] and to prevent clinical mastitis. The antibiotic should be effective against gram-positive and gram-negative bacteria and resistant against penicillinase [36].
5. Insert a sterile silicone implant (SIMPL silicone implant [www.profs-products.com]) (Fig. 4) into the teat canal to prevent adhesions and to keep the teat canal patent. Fewer pathogens were detected after the use silicone implants than after the use of wax inserts [37]. Pipe cleaners ("teat dilators") and teat cannulae caused injuries in the teat (Fig. 5) [38–40], they were contaminated with bacteria [41], and they increased somatic cell count (SCC) and the risk of detecting pathogens in the milk [40,42]. Pipe cleaners slipped into the teat and acted as foreign bodies [43]. The removal of a teat cannula caused rupture and eversion of teat canal skin [40]. (The teat canal skin often has been referred to as *mucosa*; however, this term is not appropriate here with regard to evolution,

Fig. 4. SIMPL—silicone implant.

structure, and function [44]. The teat canal skin is a part of the outer skin that has been pulled into the inner teat. Its structure is similar to the outer skin: Epidermis and corium make up teat canal skin and outer skin [45].)

6. Bandage the teat with elastic adhesive tape (Teat Bandage [www.kruuse.com]) to prevent the silicone implant from falling out and to indicate to the herdsman not to milk this teat. Apply this procedure on the day the injury occurred (day 0), 3 days later (day 3), and 6 days later (day 6). Rest and do not milk the teat from the day the injury had occurred until 9 days (day 9) thereafter (Table 1).

The milk may appear watery, and milk yield may decrease after resting the teat. Milk appearance returns to normal, however, and milk yield increases after milking is resumed. The earlier in lactation the teat was rested, the better milk yield returned to normal [46]. Resting the teat did not

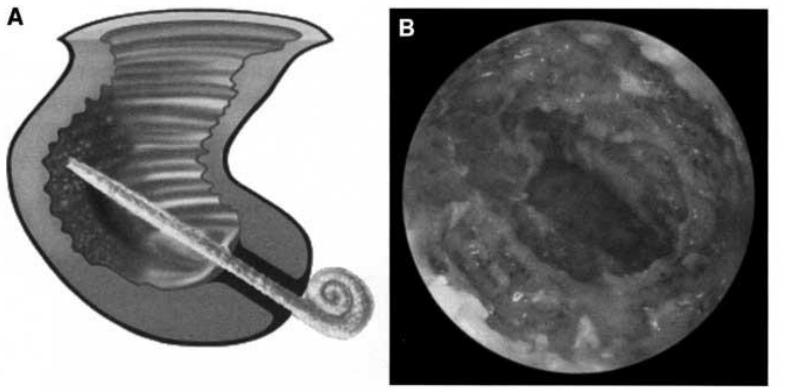

Fig. 5. (*A*) Inflammation of the teat cistern lining—"pipe cleaner disease" (schematic representation). (*B*) Inflammation of the teat cistern lining (canal theloscopy).

Table 1
Resting the teat for 3 × 3 days

Day	0	1	2	3	4	5	6	7	8	9
Administer xylazine and oxytocin	x			x			x			
Clean and disinfect the teat	x			x			x			
Drain the milk	x			x			x			
Administer an antibiotic	x			x			x			
Insert the silicone implant	x			x			x			
Bandage the teat	x			x			x			
Resume milking										x

increase the risk of mastitis [29]. If the teat is not milkable after conservative therapy, surgical therapy may be applied, the teat may be dried off, or the cow may be culled.

Surgical therapy

Precise diagnosis is a prerequisite for successful surgical therapy. In rural veterinary practice, a sufficiently precise diagnosis may be made with the help of theloscopy. Four procedures have been described: classical theloscopy by Medl et al [47–50] (equipment available from www.drfritz.de), theloresectoscopy by Hospes and Seeh [51–55] (equipment available from www.karlstorz.de), triangulation by Hirsbrunner and Steiner [56,57], and wireless theloscopy by Querengässer and Geishauser [58,59] (equipment available from www.eickemeyer.de). A film on wireless theloscopy is available on DVD [60] (www.lehmanns.de).

Procedure

The cow is administered xylazine and oxytocin and properly restrained in a claw trimming chute (Fig. 6) or on a tilt table. After cleaning and disinfection of the teat, a rubber ring is placed at the teat base, an anesthetic

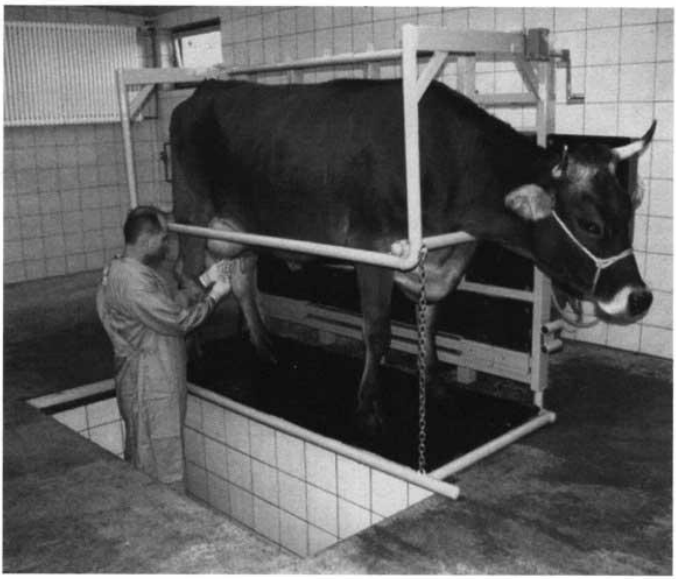

Fig. 6. Fixing the cow in claw trimming chute and examining the teat from a pit.

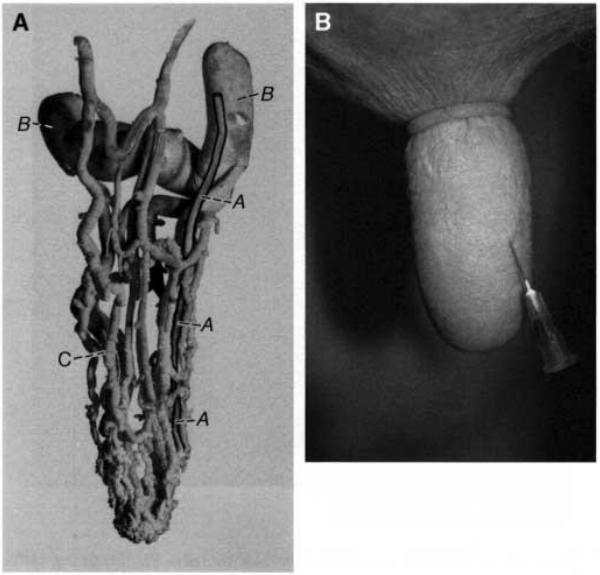

Fig. 7. (*A*) Blood vessels in the teat: artery (A), Fürstenberg vein ring (B), and veins (C), plastoid. (*From* le Roux JMW, Wilkens H. Beitrag zur Gefäßversorgung des Euters der Kuh. Dtsch Tierärztl Wschr 1959;66:429; with permission.). (*B*) Rubber ring around the teat basis: puncture of a teat vein to inject 5 to 10 mL of a 2% lidocaine solution.

is injected into a teat vein (Fig. 7), the milk is drained from the teat (Fig. 8), and the cistern is rinsed with sterile saline. Theloscopy can be performed through either the teat canal (canal theloscopy) or the lateral teat wall (lateral theloscopy) (Figs. 9–11). For lateral theloscopy, an opening is made in the teat wall, and a slide pipe is inserted (Fig. 12). The teat is dilated by pumping air into the teat. When theloscopy is performed through the teat canal, the teat canal (Fig. 13) and the teat cistern (Fig. 14) can be visualized in an upward direction. When theloscopy is performed through the lateral teat wall, the teat cistern, the inner opening of the teat canal, and the Fürstenberg rosette [45] can be visualized in a downward direction (Fig. 15).

Patients presented to the Veterinary Clinic Babenhausen, Germany, were predominantly young Braunvieh cows kept in tie-stall barns and belonging to herds with an average herd size of 38 cows. These patients were at a median of 3 months in milk and mostly pretreated. Predominantly hind teats were affected by an acute milk flow disorder. In 96% of the affected teats, a rupture in the area of the teat canal was diagnosed, 49% with tissue dislocation (see Fig. 2) and 47% without tissue dislocation (see Fig. 1); 4% had other diagnoses, such as ruptures in the teat cistern area or papilloma [61,63]. In 64% of the affected teats, an inflammation of the teat lining ("pipe cleaner

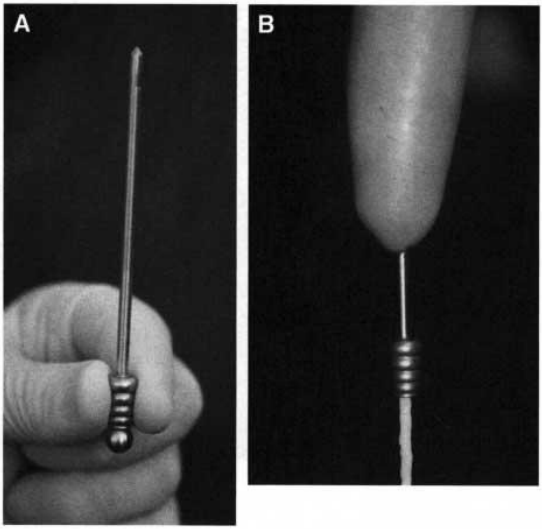

Fig. 8. (*A*) THELOKAL—extra-wide milking tube. (*B*) Draining milk.

disease") was visible (see Fig. 5) [32]. Of the affected quarters, 67% showed the signs of subclinical mastitis (SCC >100,000/mL and pathogens detected). In 67% of the milk samples from affected quarters pathogens were detected: 80% major pathogens (38% *Streptococcus* esculin positive, 24% *Streptococcus* esculin negative, 10% *Staphylococcus aureus*, 7% coliforms, 1% *Streptococcus*

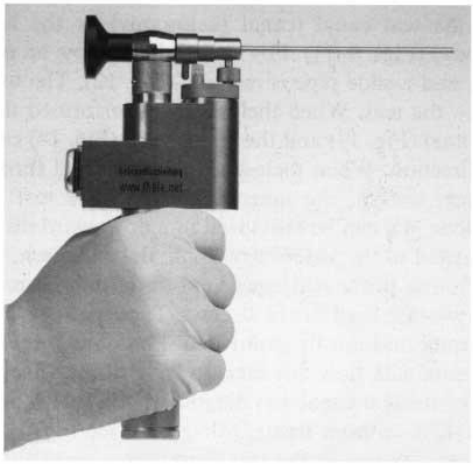

Fig. 9. THELOSCOPE—wireless teat endoscope.

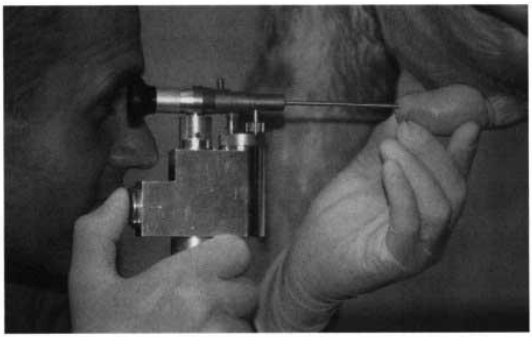

Fig. 10. Theloscopy via the teat canal (canal theloscopy).

agalactiae), 16% minor pathogens (16% *Staphylococcus* species), and 4% uncommon pathogens (4% *Arcanobacter pyogenes*) [35].

Minimally invasive surgical therapy was performed with the help of theloscopy. Ruptured and dislocated tissue was precisely removed by using a teat punch (Fig. 16). Narrowed teat canals were dilated with Hug's teat lancet (Fig. 17) [63,64]. Papilloma were extracted by using teat forceps (Fig. 18) [60]. After surgery, the artificial opening was sutured, the rubber ring was removed, and all milk was drained with an extra-wide milking tube (see Fig. 8). The affected teat was administered a mastitis antibiotic preparation, and a silicone implant was inserted into the teat canal (see Fig. 4). Then the suture was removed again, and the teat was bandaged and rested for several days to speed up healing (see Table 1).

Fig. 11. Theloscopy via the lateral teat wall (lateral theloscopy).

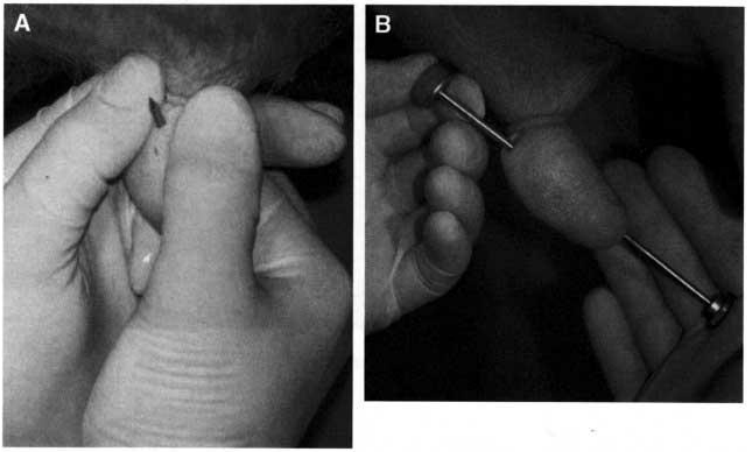

Fig. 12. (*A*) Opening the lateral teat wall using a trocar. (*B*) Insertion of the slide pipe along the trocar.

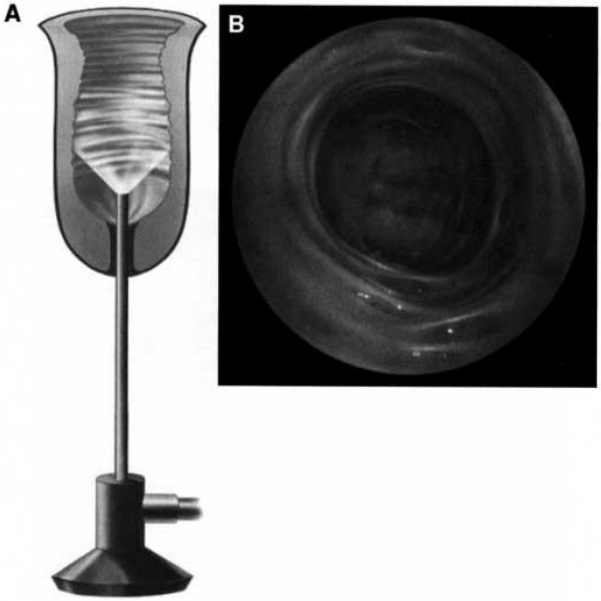

Fig. 13. (*A*) View into the teat cistern via the teat canal (schematic representation). (*B*) Normal teat cistern (lateral theloscopy). Note circular folds.

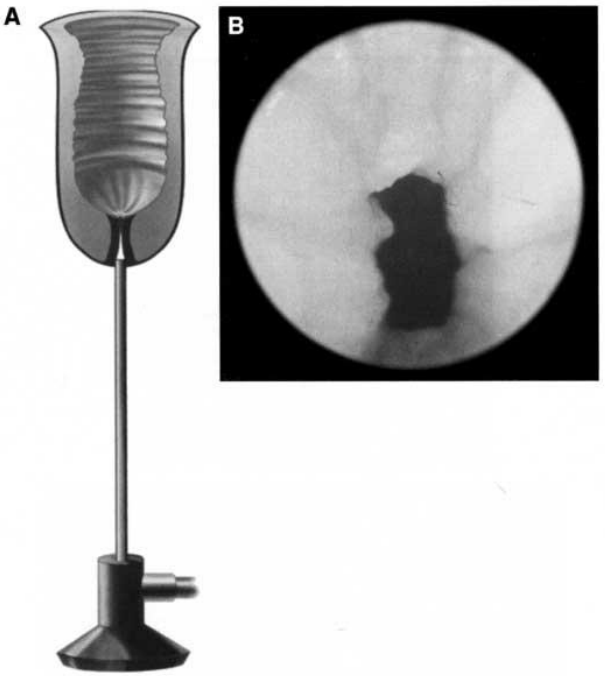

Fig. 14. (*A*) View into the teat canal via the teat canal (schematic representation). (*B*) Normal teat canal (canal theloscopy). Note longitudinal folds.

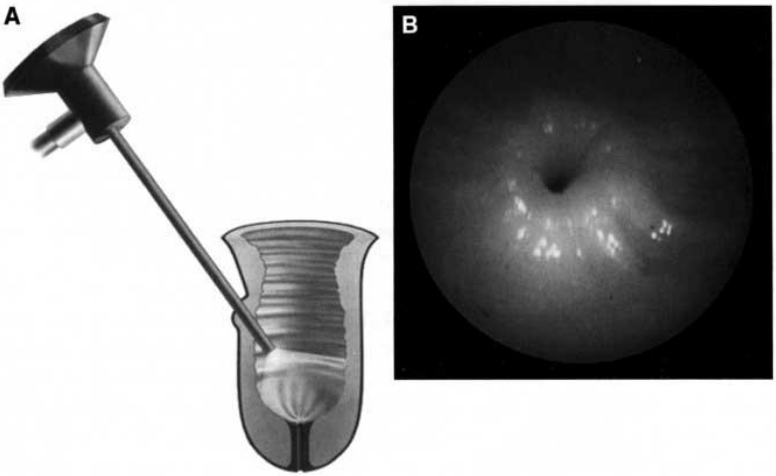

Fig. 15. (*A*) View into the teat cistern via the lateral teat wall (schematic representation). (*B*) Inner opening of the teat canal—Fürstenberg rosette (lateral theloscopy). Note radial folds.

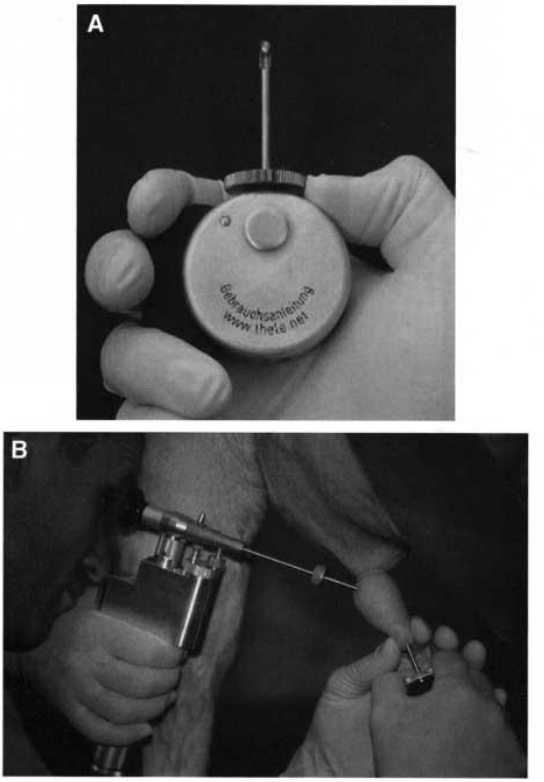

Fig. 16. (*A*) THELOTOME—teat punch. (*B*) Monitoring via lateral theloscopy. (*C*) Removal of inverted tissue (schematic representation). (*D*) Removal of inverted tissue (lateral theloscopy).

Before surgery, peak milk flow from teats with milk flow disorders was on average 24% (22%, 22%) compared with the contralateral (ipsilateral, diagonal) teats; 1 month later, peak milk flow was 73% (68%, 69%); and 6 months later, peak milk flow was 82% (77%, 80%) (Fig. 19). These values may indicate that milk flow from the affected teats was decreased before surgery and increased thereafter. Milkable yield from the affected quarters was minimal before surgery. The milked plus drained yield from the affected teats was on average 115% (106%, 107%), however, compared with the contralateral (ipsilateral, diagonal) teats before surgery; the yield was 67% (69%, 68%) 1 month later; and the yield was 69% (74%, 73%) 6 months later. These values may indicate that milk had congested in the affected quarter before surgery and that the affected quarter did not entirely meet the milk production of not affected quarters after surgery [61,62]. SCC in the

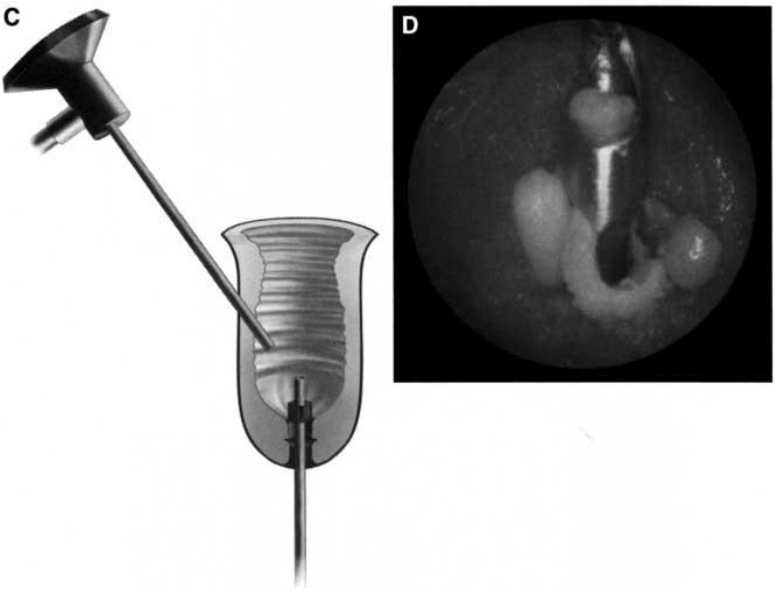

Fig. 16 (*continued*)

milk from affected teats was on average 2.9 million/mL before surgery, 725,000/mL 1 month later, and 426,000/mL 6 months later; SCC in the milk from contralateral (ipsilateral, diagonal) teats was on average 157,000/mL (124,000/mL, 127,000/mL) before surgery, 71,000/mL (49,000/mL, 55,000/mL) 1 month later, and 67,000/mL (45,000/mL, 64,000/mL) 6 months later (Fig. 20). Pathogens were detected in the milk from affected teats in 67% of the cases before surgery, in 69% 1 month later, and in 61% 6 months later; pathogens in the milk from contralateral (ipsilateral, diagonal) teats were found in 17% (13%, 15%)% of the cases before surgery, in 24% (15%, 13%) 1 month later, and in 22% (17%, 10%) 6 months later (Fig. 21). These values may indicate that milk quality from affected quarters was decreased before surgery; SCC decreased significantly after surgery; however, infection with pathogens did not change significantly [35,65].

In the lactation the injury occurred and in the subsequent lactation, affected cows yielded as much milk as nonaffected herdmates on test day (Fig. 22) and throughout lactation. Covered teat injuries increased test day SCC (Fig. 23), however, on average by 128,000/mL. Covered teat injuries that were managed surgically as described did not affect survival in the herd or calving interval (Fig. 24) [14,66].

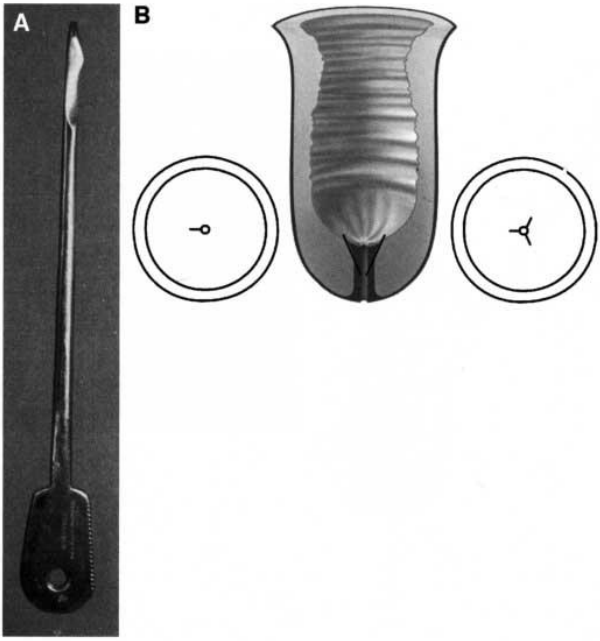

Fig. 17. (*A*) Hug's lancet. (*B*) Widening the teat canal with one, two, or three incisions in the area of the inner teat canal opening (schematic representation).

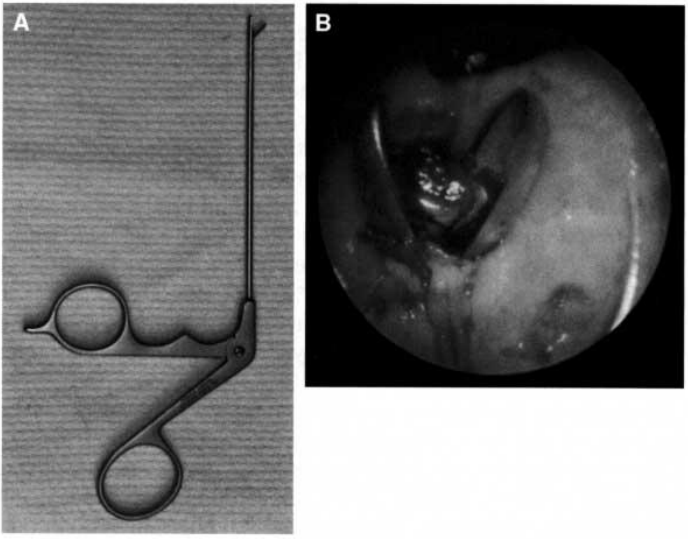

Fig. 18. (*A*) THELAB—teat forceps. (*B*) Removal of tissue with a forceps (lateral theloscopy).

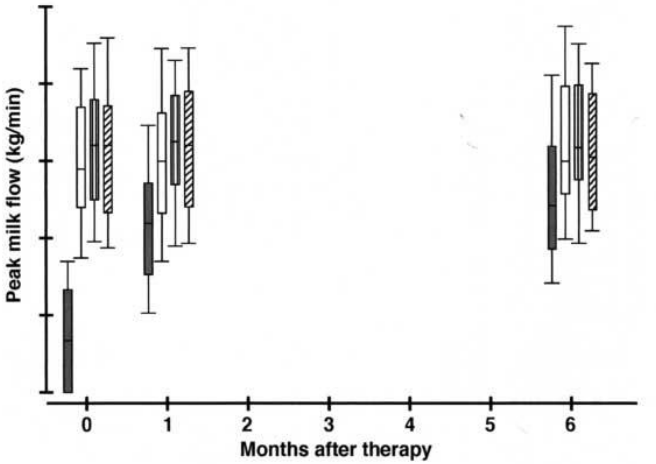

Fig. 19. Peak milk flow from the affected (■), contralateral (□), ipsilateral (▥), and diagonal (▨) teats before treatment, 1 month later, and 6 months later. (*From* Querengässer J, Geishauser T, Querengässer K, et al. Untersuchungen zu Milchfluß und Milchmenge aus Zitzen mit Milchabflußstörungen. Prakt Tierarzt 2002;83:1008; with permission.)

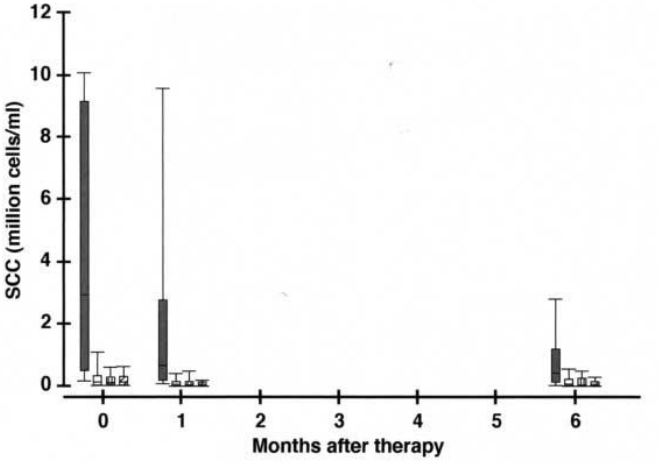

Fig. 20. Somatic cell count in the milk from the affected (■), contralateral (□), ipsilateral (▥), and diagonal (▨) teats before treatment, 1 month later, and 6 months later. (*From* Querengässer J, Geishauser T, Querengässer K, et al. Untersuchungen zur Güte der Milch aus Zitzen mit Milchabflußstörungen. Prakt Tierarzt 2003;84:606; with permission.)

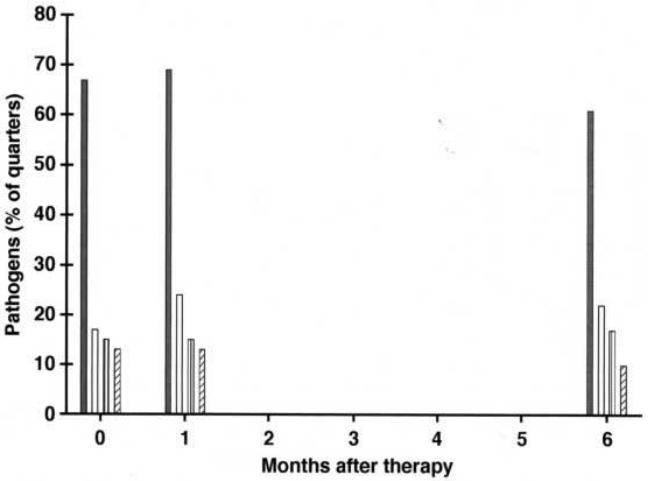

Fig. 21. Detection of pathogens in the milk from the affected (■), contralateral (□), ipsilateral (▥), and diagonal (▨) teats before treatment, 1 month later, and 6 months later. (*From* Querengässer J, Geishauser T, Querengässer K, et al.: Untersuchungen zur Güte der Milch aus Zitzen mit Milchabflußstörungen. Prakt Tierarzt 2003;84:606; with permission.)

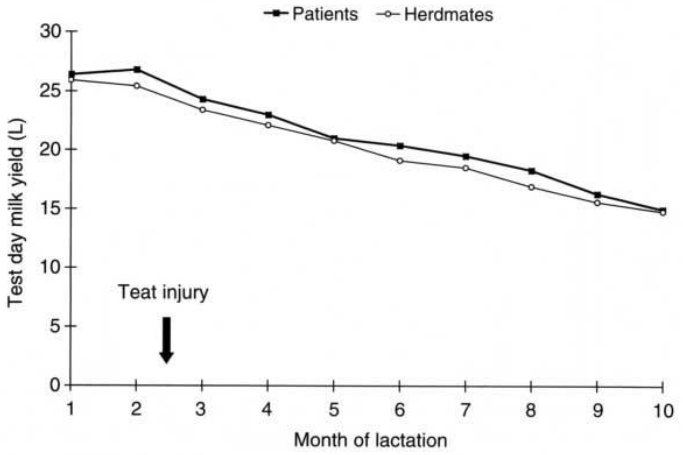

Fig. 22. Test day milk yield in the year the injury had occurred for patients and herdmates. (*From* Geishauser T, Querengässer K, Nitschke M, et al. Milk yield, somatic cell counts and risk of removal from the herd for dairy cows after covered teat canal injury. J Dairy Sci 1999; 82:1482; with permission.)

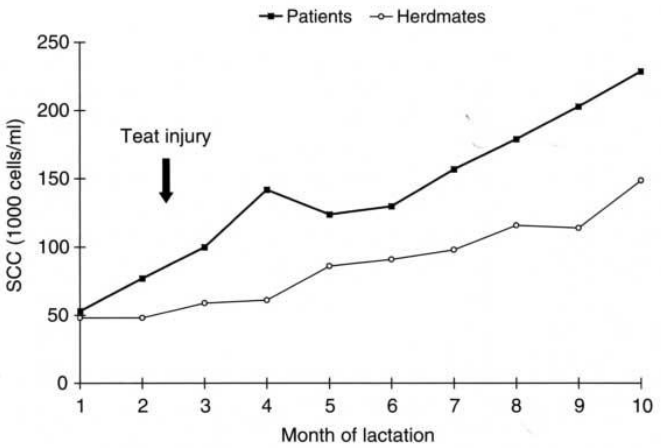

Fig. 23. Somatic cell count in the year the injury had occurred for patients and herdmates. (*From* Geishauser T, Querengässer K, Nitschke M, et al: Milk yield, somatic cell counts and risk of removal from the herd for dairy cows after covered teat canal injury. J Dairy Sci 1999; 82:1482; with permission.)

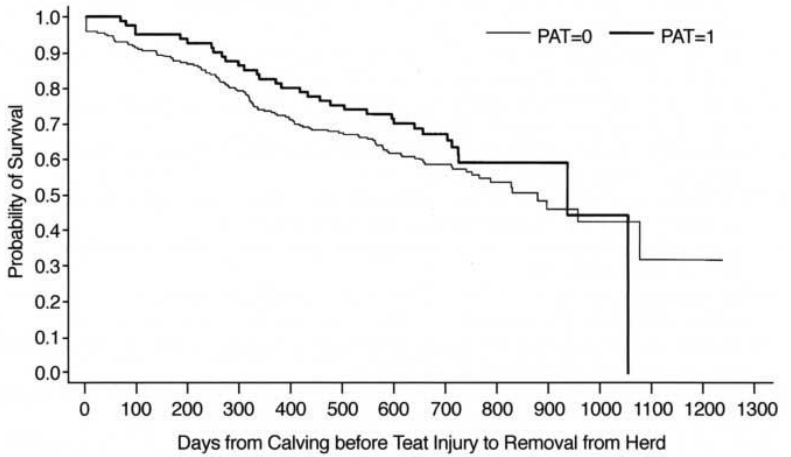

Fig. 24. Survival of patients and herdmates. (*From* Geishauser T, Querengässer K, Nitschke M, et al: Milk yield, somatic cell counts and risk of removal from the herd for dairy cows after covered teat canal injury. J. Dairy Sci 1999;82:1482; with permission.)

Summary

Teat endoscopy (theloscopy) is a useful technique for diagnosis and therapy of covered teat injuries. Minimal invasive theloscopic surgery may help to restore milk flow, milk yield, and SCC of the affected quarter. Infection with pathogens may not change significantly, however. Cows treated as described may yield as much milk as their herdmates at a slightly increased udder SCC and stay as long in the herd as their herdmates. Theloscopy also may be used for diagnosis and therapy of various other teat disorders [32,38–40,42,43,48,49,52,54,67–80].

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