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URETEROSCOPIC AND SCANNING ELECTRON MICROSCOPICAL FINDINGS IN URETERAL ANASTOMOSES AFTER SEGMENT RESECTION

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Abstract

In an experimental study on 8 canine ureters, end-to-end anastomoses were performed after segmental resection between 9 and 13 cm, using two different surgical techniques. After 3 months of observation the three-dimensional structure of the anastomosis and the surrounding areas was investigated by ureteroscopy and scanning electron microscopy. 3 types could be differentiated by the morphologic features of the ureteral lumen: normal width, segmental stricture, and circumferential stricture. The results offer a plausible explanation for the occasional discrepancy between histologic findings of relatively normal lumen width, and functional disorders apparently reflecting ureteral stenosis. They further support that excellent functional and morphologic reconstruction can be achieved even under the extreme conditions of 13 cm segmental resection with obligatory anastomosis under tension. The findings connected with dilatations observed distal to the anastomotic site appear rather contradictory, their interpretation is difficult.

KEY WORDS: Ureteral End-to-End Anastomosis, Segmental Resection, Ureteroscopy, Scanning Electron Microscopy, Microsurgery, Spatial Structure of Anastomosis

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Introduction

The results of experimental end-to-end anastomoses of the ureter are currently evaluated in terms of functional recovery and morphological reconstruction. The diameter of the ureteral lumen in the anastomosed area represents the actual flow resistance with its decisive influence on urine transport. The results of excretion urography are sometimes in striking conflict with the luminal width within the anastomosis (Lutzeyer, 1956; J. Pohl, unpublished results), that is, even serial histologic sections of the anastomotic site fail to reveal the luminal narrowing that could be expected from X-ray findings. This suggests that the three-dimensional structure of the anastomosis, insufficiently documented in serial cross sections of the ureter, must have an essential influence on ureteral function.

The present experimental study intends to elucidate certain problems that had emerged from the histologic work-up of ureteral anastomoses on larger resected specimens (3 - 10 cm) in a previous study. The dynamic and morphologic data from ureteroscopy will be correlated with and supplemented by findings in scanning electron microscopy (SEM).

Materials and Methods

The assay was carried out with 4 mongrel dogs of 26 - 36 kg body weight. 8 end-to-end anastomoses were performed in the lower half of the ureter (4 - 5 mm diameter) from which, after complete retroperitoneal mobilization, segments of 9 to 13 cm length had been resected. The oblique anastomoses were executed with two modifications: 1) all layer interrupted sutures without optical monitoring (n = 2), and 2) submucous interrupted sutures using a surgical

microscope (n = 6), using monofil synthetic, resorbable polydioxanon material (PDS of ETHICON).

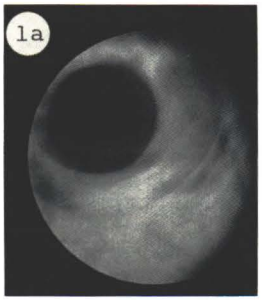
After an observation period of 3 months, during which various functional tests (excretion urography, isotope clearance, urodynamic measurements, etc.) had been performed, the animals were anesthesized and laparotomied. The bladder was mobilized to permit retrograde endoscopy of the ureters from the opened bladder with a HOPKINS pediatric straight forward telescope (2.7 mm diam.). Diuretic stimulation (Furosemide, 10 mg IM) resulted in clarification of the urine, facilitating observation and photographic documentation, and also transitory stimulation of peristaltic activity. Subsequently the anastomosed parts were removed, opened longitudinally, and fixed in glutaraldehyde buffer (Sörensen buffer, pH 7.3). Rinsing with Sörensen buffer was followed by dehydration in graded alcohols and drying at the critical point. The samples were stored in an exsiccator until final processing and preparation on the sample board with a special glue (Leit-C acc. to GÖCKE). The surface of the slides was spattered with gold. Scanning electron microscopy was performed with a Stereoscan 180 (CAMBRIDGE) at 20 kV.

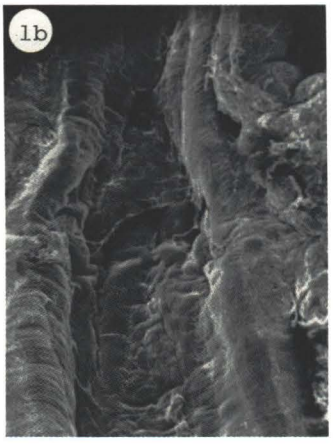
Results

The morphologic features of the anastomoses were classified in three categories: Type 1: No essential stricture of the ureteral lumen; type 2: partial or segmental stricture of the lumen without essential obstruction of urinary flow; and type 3: distinct circumferential stricture of the ureteral lumen.

The four anastomoses of type 1 had been performed in microsurgical technique. In ureteroscopy, the transitional zone between proximal and distal ureter showed a minor crest only under maximum diuresis and permanent dilatation of the ureteral lumen (Fig. 1a), which could not be demonstrated so well in scanning electron microscopy (Fig. 1b,c).

Endoscopic monitoring of urine transport revealed completely unimpeded passage of the contraction ring under





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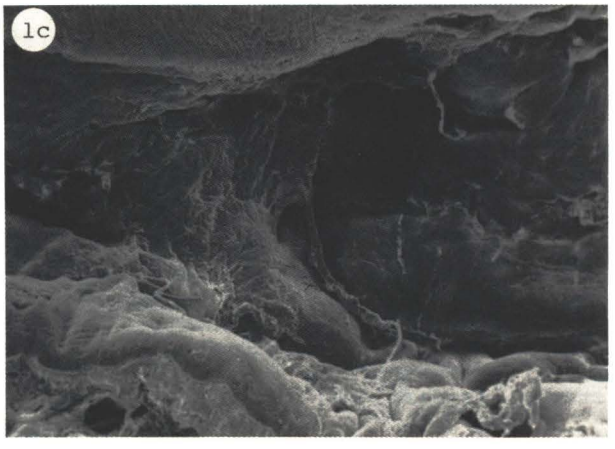


Fig.1: Microsurgical end-to-end anastomosis (type 1), 3 months after resection of a 13 cm segment.

a) Ureteroscopy: the anastomosis appears as a clear ridge stenosing the lumen only slightly under maximum diuresis.

b) SEM overview in lower magnification: the cranial part of the ureter (top) goes into the slightly dilated distal part via a small step formation.

c) Higher magnification of b).

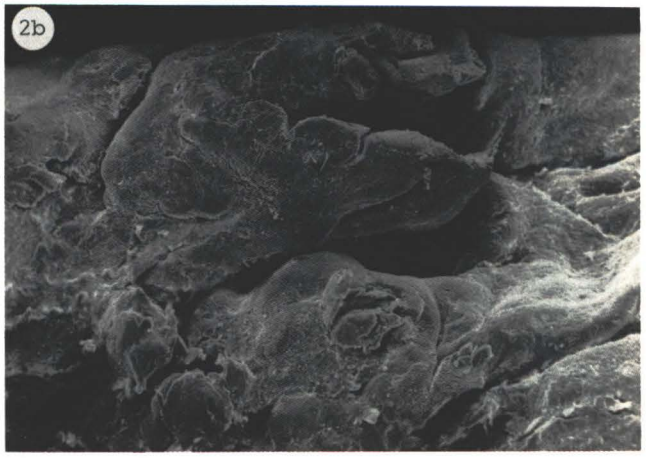
d) In the dilated part we see numerous horizontal folds, an otherwise uncommon feature of the urothelium.

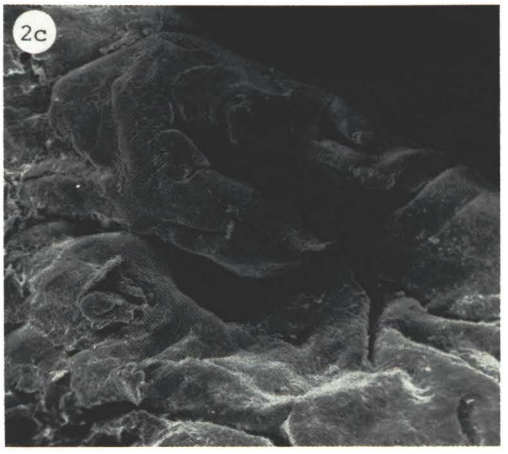
Fig.2: Microsurgical anastomosis (type 2) after resection of a 9 cm segment.

a) Ureteroscopy: broad-based, polypous structure, mobile in the flowing urine. Photo width (P.W.) = 6 mm

b) SEM overview (left: distal ureter, right: cranial ureter): The polyp (center) lies now close to the ureteral wall. P.W. = 3.1 mm

c) Same specimen, seen from a more cranial point. P.W. = 3 mm





normal diuresis. In two of these cases, the portion distal from the anastomosis appeared moderately dilated in SEM, and only in these areas did we find some unusual horizontal folds among the otherwise longitudinal folds of the urothelium (Fig. 1d).

Partial or segmental stenosis of the lumen, classified as type 2, was observed in two other microsurgical anastomoses. While ureteroscopy revealed smooth walls and no signs of scarred stenosis in most areas of the anastomoses, some polypous formation, arising from a small or broad basis in the ureteral wall, and mobile in the urine bolus, was found to protrude into the lumen without impeding the urine transport in a recognizable way (Fig. 2a). In scanning electron microscopy, however, the anastomosis as a whole appeared slightly stenosed (Fig. 2b).

The two anastomoses of type 3 with marked circumferential stricture of the lumen, had been executed with an all-layer-interrupted technique without optical monitoring. Endoscopic examination could reveal only a slight opening of the narrowed lumen (Fig. 3a,b). Corresponding SEM documented 4 to 5 ridges bulging into the lumen (Fig. 3c,d). In the clefts between those bulges which go down to normal wall levels, we observed numerous urothelial lamellae with narrow bases (Fig. 3e,f). It was noted that these stenosed anastomoses failed to show any distal dilatation.

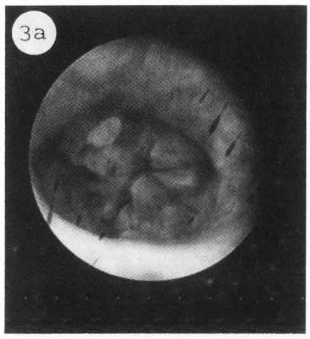
All anastomoses had crypts or fistular ducts with urothelial lining which ended in different layers of the ureteral wall; they were particularly deep and numerous in type 3 anastomoses (Fig. 4).

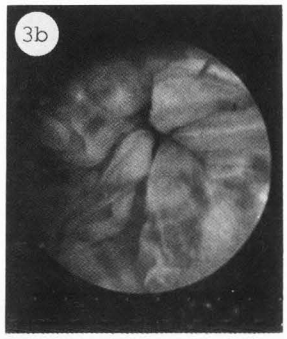
Further remarkable features were the lateral aspect of the urothelium observed in only one section margin (Fig. 5a,b) and, in two cases with more pronounced obstruction, some urothelial injuries that were probably due to ureteroscopy (Fig. 6).

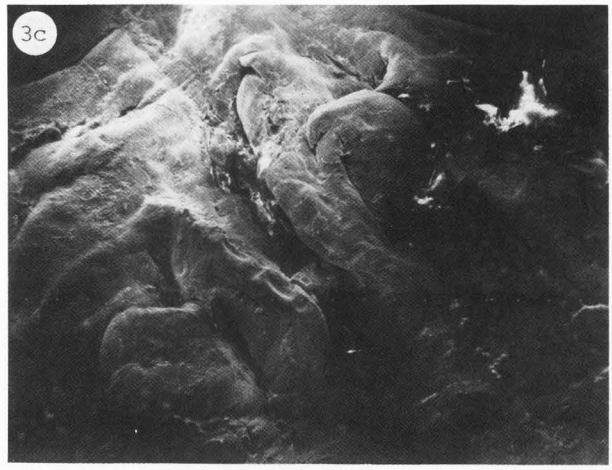
All results of types 1 and 2 showed rapid and complete postoperative recovery of renal and ureteral functions within 2 to 3 weeks. Even in the late results of type 3 the transport functions were surprisingly good despite the stenosis documented in ureteroscopy. The essential difference to types 1 and 2 results is seen in the very late restoration to the preoperative level of renal and ureteral function, which took 6 to 8 weeks.

Discussion

In a previous experimental study of 40 canine ureters, we had investigated the impact of segmental resection and tension on ureteral end-to-end anastomoses (Pohl et al., 1985). It could be shown that in the area studied (resections up to 10 cm), the actual length of the resected segment and the tension failed to influence the functional results. This is in opposition to the







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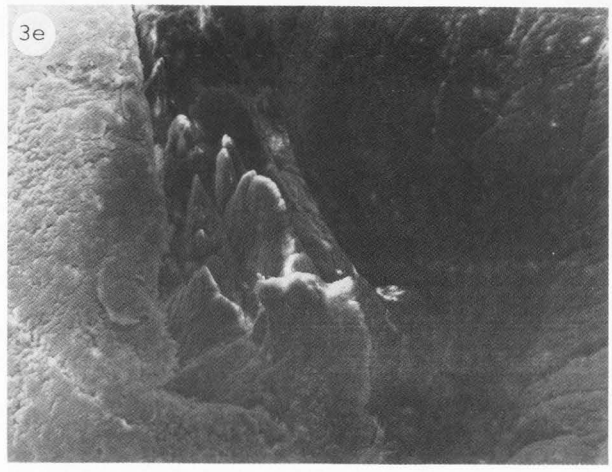


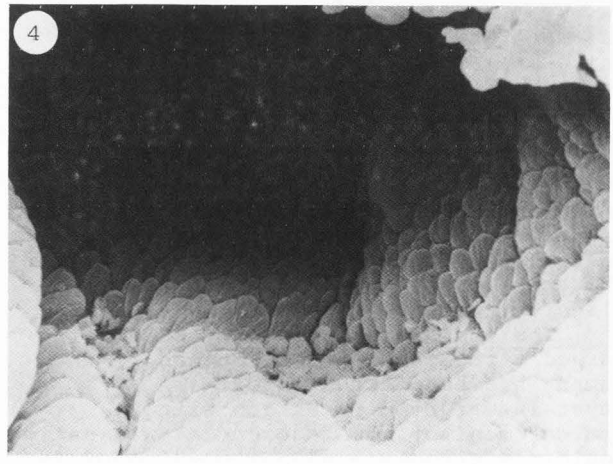
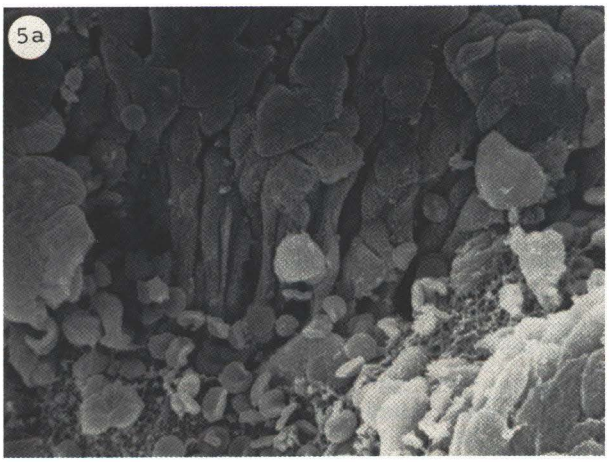


Fig. 3: Anastomosis with all-layer interrupted suture, executed without optical monitoring after resection of a 9 cm segment.

a) Ureteroscopy: strong circumferential stricture of the lumen
b) only minor opening of the lumen in the bolus
c) SEM overview: Several distinct ridges elevating over the normal wall level
d) Segment magnification of c)
e,f) numerous slim-based lamellae between the ridges

Fig. 4: Deep fistula with epithelial lining P.W. = 0.24 mm



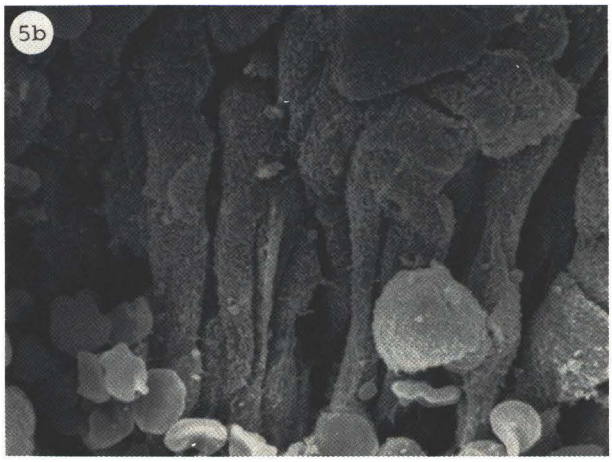


Fig. 5: a,b) Vertical structures of the multilayered urothelium
Photo Widths: a: 0.11 mm; b: 0.05 mm.

Fig. 6: Urothelial injuries probably due to ureteroscopy P.W. = 0.46 mm

opinion of other authors (Lutzeyer, 1956; Küss and Chatelain, 1975).

When we correlated the functional results with the diameter of the ureteral lumen assessed in histologic cross sections of the anastomotic site (J. Pohl, unpublished results), we noticed in some cases a certain discrepancy which prompted us to study the three-dimensional structure of this area more closely.

So far, no ureteroscopic data about ureteral anastomoses have been described. By our essentially rather simple method (modified after Bush et al., 1981) the primary spatial structure of the anastomotic site could be ascertained in detail, and its dynamism studied under various conditions of diuresis. A certain disadvantage of the method is seen in the fact that segments with stronger strictures can be evaluated only by way of the respective distal portions.

In the first and so far, unique SEM study of ureteral anastomoses, Jonas et al. (1981) had investigated the absorbability of suture material and the role of different microsurgical techniques. Our SEM results confirm the assumption that the spatial structure of the anastomosis must have a considerable influence on ureteral function. From the endoscopic and SEM data of a type 3 anastomosis (Fig. 3 a-d), one would predict that a histologic cross section should reveal a stellate lumen with only minor stenosis.

The "urothelial cysts" often described in the submucosa and muscular layer demonstrated on histologic cross sections are now identified as fistular ducts from the ureteral lumen, but it is still unclear whether, besides disturbing the muscularis structure, they can also effect a functional impairment.

It was rather unexpected that ureteral dilatations in the immediate distal vicinity of the anastomosis, as described by several authors (Boyarsky and Labay, 1972; Vereecken et al., 1975; Jonas et al., 1981) were found only in those of our cases that showed excellent functional results (Fig. 1c), whereas none of the cases with slight or moderate stenosis would show any dilatation of the area distal to the anastomotic site.

The mechanism responsible for this phenomenon is still unexplained. In previous investigations (J. Pohl, unpublished results) the frequency of distal dilatation was maximally 50%, dependent on the surgical technique chosen. These observations suggest that the term of "poststenotic dilatation", adopted from vascular pathology, should be abandoned in favor of a more neutral term like "distal dilatation" for the respective ureteral changes. The transversal urothelial folds observed in the dilated portions, but nowhere else in

the ureter (Fig. 1c), and which will merge again into the usual longitudinal folds (Woodbourne and Lapides, 1972) of the urothelium after a length of some 10 mm, might be attributed to the effect of flow conditions, but as well to the immediate effects of the dilatation proper. The possibility of artefacts, too, should always be considered.

The collective studied in this assay is too small to warrant statistical evaluation. The results, however, may emphasize the possibility to achieve excellent functional and morphological reconstruction even under the extreme conditions of resecting a segment of 13 cm (Fig. 1a,b), and the necessary anastomosis under tension.

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Discussion with Reviewers

D. Jones: Why should partial ureteral stenosis secondary to repair affect SEM of the mucosa?
Authors: Any kind of stenosis will affect the spatial structure of the lumen, and thereby alter the SEM appearance of the mucosa.

D. Jones: What does segmental stricture mean anatomically? Polyps?
Authors: We have seen polyps, epithelial hyperplasias, and granulomas.

D. Jones: How do you know how much tension was placed on each repair?
Authors: The tension was determined indirectly by way of the approximation distance of ureter ends. (Pohl et al., 1985, text reference).

D. Jones: Have you considered the possibility of fixing your specimens of ureter by gently distending the lumen with fixative in order to better visualize the epithelial diverticula you have described?
Authors: The possibility was considered, but we were afraid it might provoke essential alterations and additional artefacts.