Urol Res (1984) 12:115–119

Urological Research

Segmental Ureteric Replacement: An Animal Study Using a Free Non-Pedicled Graft

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Accepted: October 24, 1983

Summary. An animal study has been carried out on 3 baboons to assess the feasibility of replacing a damaged segment of ureter with a free, non-pedicled, full thickness graft. A 3 cm segment was excised from the middle third of one ureter from each baboon and the free graft (buccal mucosa) fashioned into a tube and interposed between the cut ends in order to replace the excised segment. The grafts were left in situ for up to 10 weeks and their subsequent fate studied radiologically, histologically and by gross specimen examination. The results showed that in all cases perfect viability of the graft was maintained and there was no evidence of graft shrinkage or of loss of patency. In one instance a stricture developed at the mid point of the graft, but this was entirely explicable on technical grounds. Urine drainage was not impaired on account of the insertion of a muscle-free (and therefore aperistaltic) segment into the ureter.

Key words: Ureteric replacement, Experimental study, Buccal mucosa.

Introduction

The surgical management of ureteric strictures frequently follows a straight forward and well established course, but occasionally the situation arises where it is necessary to replace a length of ureter with bowel, or resort to autotransplantation. As an alternative to such major procedures, this study was carried out to assess the feasibility of using a free, non-pedicled graft fashioned into a tube to completely replace a short length of ureter. In this regard it was necessary to assess two factors: 1. whether such a graft would remain viable, and 2. whether shrinkage or stricturing of the graft would occur.

The study was carried out in experimental animals and this paper presents the results of this animal study.

Materials and Methods

Operations were performed on three female baboons, each of approximately 15 kg in weight, under Pentobarbitone Sodium Anaesthesia (Sagatal, May and Baker).

The free graft that was to replace the ureteric segment was taken from buccal mucosa – approximately 3 cm x 2 cm in area. The graft was completely denuded of fat and subcutaneous tissue and the buccal mucosal defect was closed with continuous 2-0 chromic catgut sutures. Through a midline incision, the ureter and kidney on one side were exposed and an approximately 3 cm length was excised from the middle third of the ureter. It was noted that throughout its length the baboon ureter was enveloped in a layer of fat which produced some technical problems at the time of graft insertion.

A size 5 French gauge Silastic stent was introduced into the ureter extending from the bladder to the renal pelvis and out through the renal parenchyma to the skin. (Perforations were made in that part of the tube that was to be situated in the renal pelvis to allow urine drainage through the tube). At skin level the tube was ligated and buried subcutaneously to prevent the baboon from removing the tube prematurely. Over this stent the buccal mucosal graft, 3 cm in length was fashioned into a tube, with mucosa forming the luminal aspect, and interposed between the two cut ends of the ureter. Anastomosis was secured with 5-0 Polyglycollic Acid (Dexon) sutures. Once the anastomosis was complete the graft was covered with pedicled omentum to provide vascularity [5]. Closure of the abdomen was in layers with corrugated drainage to the anastomosis.

Despite the oral surgery (the ureteric grafts were taken from the buccal mucosa) resumption of solid feeding occurred on the first post-operative day in two of the animals and on the fifth day in the remaining one (baboon no. 1).

On the fifth post-operative day, the baboons were again anaesthetised in order to remove the corrugated drain and to reposition the ureteric stent. The tip of the stent, previously situated in the bladder, was advanced under fluoroscopic control to lie in the renal pelvis and act as a nephrostomy, where it remained for subsequent radiological examinations of the ureter. The excess tubing at skin level was cut off and the external end again ligated and buried subcutaneously.

After periods of 4, 8 and 10 weeks antegrade ureterograms were performed through the repositioned stents and the animals submitted to laparotomy for removal and subsequent examination of the kidney and ureter on the grafted side. By 8 weeks post-operation, baboon no. 2 had removed the ureteric stent and ureterograms on this animal had to be performed retrogradely.

Fig. 1. Baboon No. 1. Nephrostogram 10 weeks after graft insertion. Note redundancy of graft and absence of ureteric dilatation proximal to the graft

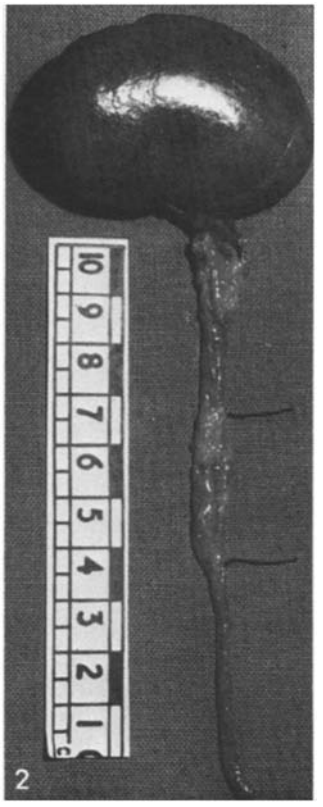

Fig. 2. Baboon No. 2. Gross specimen 8 weeks after graft insertion. The extent of the graft is indicated by the silk ties

Results

The assessment of graft survival and patency was based on:

1. radiology – ureterograms.
2. examination of the gross specimen.
3. histological examination of the grafts and adjacent ureter.

Radiology

Ureterograms were performed 10, 8 and 4 weeks after graft insertion in baboons 1, 2 and 3 respectively. In baboons 1 and 3 the study was antegrade, but baboon 2 had removed the nephrostomy tube and the ureterogram was necessarily a retrograde study performed by catheterising the distal ureter.

The ureterograms demonstrated that in all cases the grafts had remained patent. No shrinkage of the grafts occurred, and this was particularly evident in baboons 1 and 3 where there was some redundancy of the grafts at the time of surgery, and this was still present 4 and 10 weeks later (see Fig. 1).

In baboon 3, a stricture of the middle of the graft had occurred by 4 weeks. It was recognised at the time of surgery that there was tension in the graft while fashioning it into a tube. This was the only graft which was sutured under tension and we believe the stricturing to be entirely technical. Thus the radiological examinations demonstrated that:

1. all the grafts remained patent
2. no shrinkage of the graft occurred
3. except in one instance, stricture formation of the graft did not occur (in this single exception the stricture was considered to be technical – see above)

Gross Specimens

After completion of the radiological studies the baboons were sacrificed and the kidney and grafted ureter were removed for gross and histological examination.

It was evident at operative removal of the organs that the pedicled omentum had supplied the graft with excellent vascularity, and very good vascular adhesions were present. The omentum was dissected from the graft and in all cases the viability of the graft was unquestionable. Moreover, it was difficult to tell where ureter ended and graft began as such good continuity had developed between the two

Fig. 3. Normal baboon buccal mucosa. Longitudinal section. Haematoxylin and Eosin

Fig. 4. Buccal mucosal graft 10 weeks after insertion to ureter (Babbon No. 1). Haematoxylin and Eosin

(Fig. 2). From this figure can be seen that there is no evidence of any graft shrinkage.

The gross examinations confirmed that:

1. the grafts remained viable
2. excellent vascularity of the graft was obtained from the omental wrap applied at surgery
3. there was no shrinkage of the grafts
4. excellent continuity between graft and ureter was established

Histology

Once the gross specimen had been examined, the tissue was sent for histological examination. The following tissues were examined:

1. normal baboon ureter
2. normal baboon buccal mucosa
3. the area of anastomosis
4. the graft

All specimens were stained by Haematoxylin and Eosin, and Masson Trichrome prior to examination under light microscopy.

Figure 3 demonstrates normal buccal mucosa prior to insertion as a ureteric graft. Fig. 4 is a longitudinal section through the graft, 10 weeks after insertion (Baboon no. 1) and demonstrates the integrity of the epithelial surface, a lack of any significant inflammatory cell infiltrate and no gross fibrosis or collagen deposition. The one graft in which a stricture developed showed on histological examination to have a break in the epithelial surface of the graft. The histological studies thus demonstrated:

1. the free graft remained fully viable
2. the epithelial surface of the graft remained intact and unchanged from its original epithelium
3. there was no significant inflammatory cell infiltrate into the graft or the anastomotic area
4. there was no significant fibrosis or deposition of collagen in the graft
5. the one graft in which a stricture developed demonstrated a defect in the epithelial surface of the graft at the site of the stricture.

Discussion

Free grafts, as opposed to pedicled grafts, have been used for some years in the repair of urinary tract strictures, but their use has been confined to the repair of strictures of the urethra. Pressman and Greenfield [4] described the use of free penile skin (obtained by circumcision) for the repair of a single case of urethral stricture, and Devine et al. [1] ten years later reported a small series of successful repairs using this technique and thus established its role in the management of urethral strictures. The successful use of a free skin graft to replace segments of the ureter has not previously been described.

It is recognised that split skin grafts may be subject to shrinkage, and we feel it is essential to use full thickness skin grafts if shrinkage (and therefore stricturing) is to be avoided.

For this animal study, buccal mucosa rather than skin was used to replace the ureteric segment for 2 reasons. Firstly, like skin it is composed of squamous epithelium, and is readily accessible. Secondly, female baboons were used for the study because initially it was intended that the ureteric stents would be removed cystoscopically, and cystoscopy is more easily performed on female baboons.

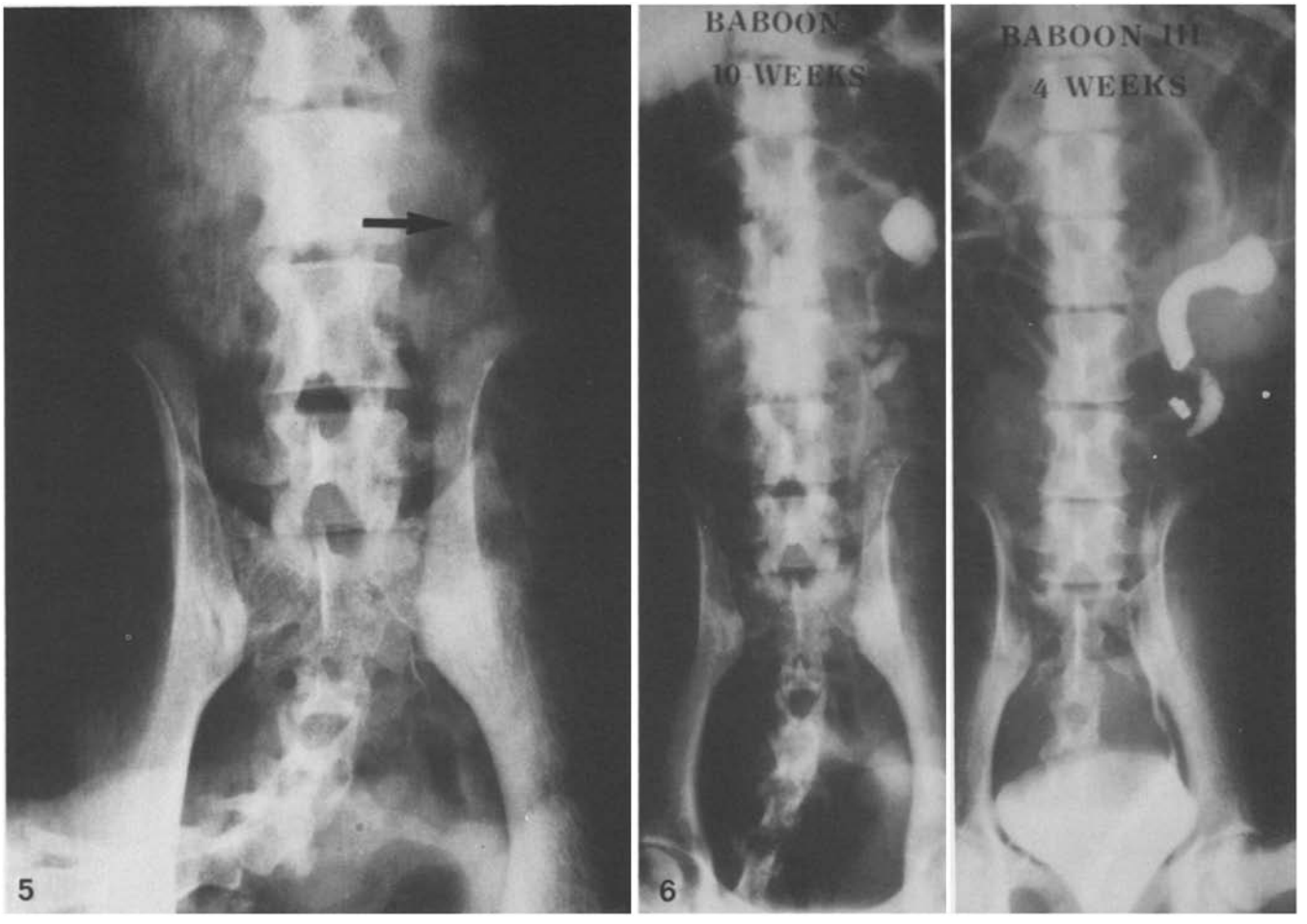

Fig. 5. Baboon No. 1. Nephrostogram post drainage film 10 weeks after insertion of graft. *Arrow* indicates minimal residual contrast in graft. Note absence of retention of contrast proximal to graft

Fig. 6. Ureterograms comparing the effect of a ureteric stricture after 4 weeks (baboon 3, *right*) with that of the insertion of a non pedicled graft in the ureter after 10 weeks (baboon 1, *left*)

The situation in the urethra is not directly comparable to that in the ureter. In the first place, the passage of urine along the urethra is not primarily dependent on inherent peristalsis but rather on the pressure generated in the bladder. Secondly, the urethra is covered by muscle which on contraction milks out the final drops of urine at the end of micturition. Thus the urethra acts as a more or less passive compressible tube, and the successful introduction of a skin graft should not materially alter the status quo. On the other hand, urine flow along the ureter is largely dependent on peristalsis within the ureter, generated by the muscular component of its own wall. Thus the introduction of a muscle-free graft to replace a segment of ureter, or to patch a scarred strictured length of ureter, produces an area in which peristalsis will be absent. Examination of the ureterograms, which were performed with the baboons anaesthetised and lying supine – a situation distinctly unfavourable for ureteric emptying – reveals that retention of contrast is not a factor and that the ureter proximal to the graft empties well (Fig. 5). Figure 6 illustrates the ureterogram at 4 weeks in baboon 3 in which a graft stricture developed, and clearly demonstrates the proximal ureteric dilatation and retention of contrast. This compares with the ureterogram of baboon 1, taken 10 weeks after insertion of a nonperistaltic graft, where no such hold up is evident. This suggests that a short length of atonicity in the ureter does not impede urine drainage, additional evidence for which is obtained from examination of excretory urograms of patients suffering from chronic Bilharzial infestation of the bladder and distal ureter. In this condition the dilatation of the lower ureter is consequent upon atonicity and loss of peristalsis in this part of the ureter [3], but as these authors demonstrated and as we have subsequently confirmed from our own examination of excretory urograms of many Bilharzial patients with ureteric involvement, there is no obstruction to drainage despite the dilatation of the distal ureter, as is evidenced by complete upper tract clearance in the erect post micturitions films.

Conclusion

This animal study has shown 3 significant features.

1. If a free full thickness graft is applied to the ureter it remains viable when covered with pedicled omentum.

2. Shrinkage of the graft does not occur so long as it is of full thickness.

3. A short muscle-free graft in the ureter does not impair urine drainage.

Acknowledgements. The authors would like to express their gratitude to Dr. Sherman Ripley and the technicians of the Department of Physiology, University of Natal, for technical assistance, to Prof. S. Kallichurum of the Department of Pathology, University of Natal, for assistance with the histological specimens, to the Department of Medical Illustration, University of Natal, for preparation of the photomicrographs and the photographic plates, and to Mrs. Gail Grier of the Department of Urology, University of Natal, for typing the manuscript.

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