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Replacement of Urinary Bladder Wall in the Cat by Autologous X-Ray Treated Full Thickness Skin Graft

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Summary. A partial urinary bladder resection was performed in 25 female cats. The defect was replaced with an X-ray treated autologous full thickness skin graft. This graft was shown to be an appropriate foundation for the rapid regeneration of transitional cell epithelium which was proven to be present after 4 weeks. Smooth muscle fibres were present in all cases after 12 weeks. Postoperatively, bladder capacity was adequate without evidence of incrustation or ossification. No changes were seen in the upper urinary tract. Compared to other types of autologous bladder wall replacement this method is simple and warrants clinical investigation.

Key words: X-ray treated skin graft, Partial urinary bladder replacement.

Introduction

Autografts are considered to be an ideal tissue substitute. Full thickness skin in contrast to superficial skin has the advantage of better mechanical strength due to its high content of elastic fibres and the risk of shrinkage is considerably reduced (2, 3, 8, 12, 15).

In previous experiments we showed the efficacy of frozen autologous full thickness skin graft (14) for bladder wall replacement. The epilation of the full thickness skin graft is essential in order to avoid urinary incrustations or the formation of bladder stones (14). When using the deep freezing method (without controlled cooling rates) however, we did not always achieve complete epilation and furthermore the freezing method was found to be quite difficult (11). Therefore a new method of pretreatment has been tried. We have found that surface X-ray treatment of the skin proves to be a satisfactory method of complete epilation.

Methods

Bladder replacement was performed in 25 young female domestic cats. Of these, 6 animals received the skin autograft without pretreatment and 19 cats were given a fractional epilation X-ray dose under Brevimythal^R-anaesthesia (10 mg/kg b. w.) to a 9 x 7 cm area of the hypogastric region over a period of about 4-5 weeks (4000 R total dose).

After a post irradiation recovery interval of 2-4 weeks, the transplantation was performed under Nembutal^R-anaesthesia (30 mg/kg b. w.).

At laparotomy the bladder was isolated from surrounding connective tissue and its wall was either subtotally or extensively resected. The autograft was sutured to the bladder wall with 4-0 chromic catgut. The epithelial surface of the autograft faced the lumen of the bladder. Urine was drained by a transurethral polyethylene catheter for 2 or 3 days.

No antibiotics were administered during recovery. One cat died with urinary peritonitis attributed to poor surgical technique.

Radiological and histological examinations were carried out postoperatively at 2 weeks, 4-6 weeks, 3 months, 6 months and 1 year. X-ray examination of the bladder was done at the beginning of spontaneous micturition (Fig. 1).

Post mortem the urinary bladders were fixed by filling with and immersion in a 5% formaldehyde solution for several days.

Results

Epilation of the skin was readily achieved by the end of the X-ray treatment. No other altera-

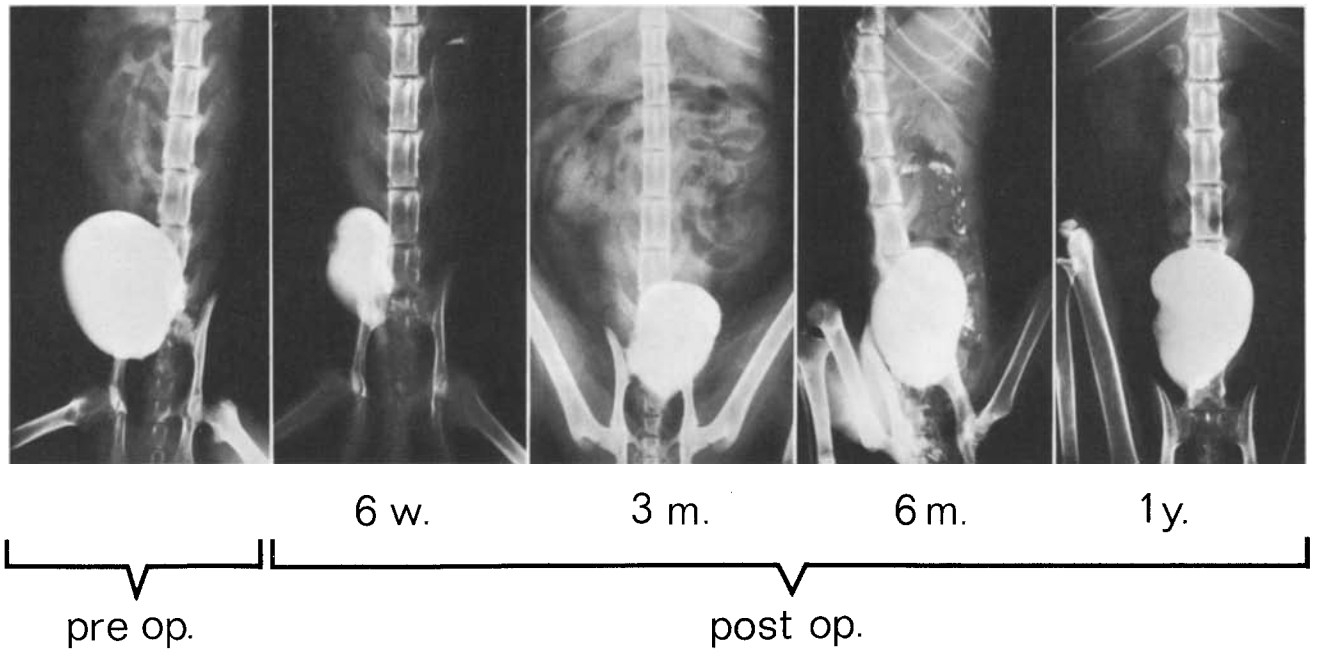

Fig. 1. Intravenous urography 90 min post injection (Cystography)

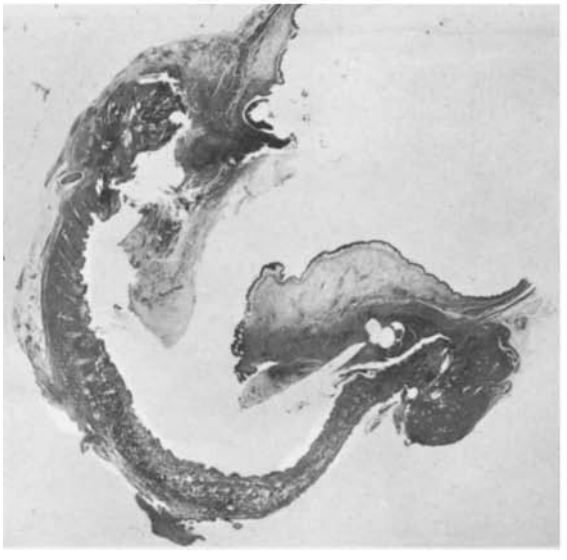

Fig. 2. Bladder cross section 2 weeks post-operatively, (3x) HE

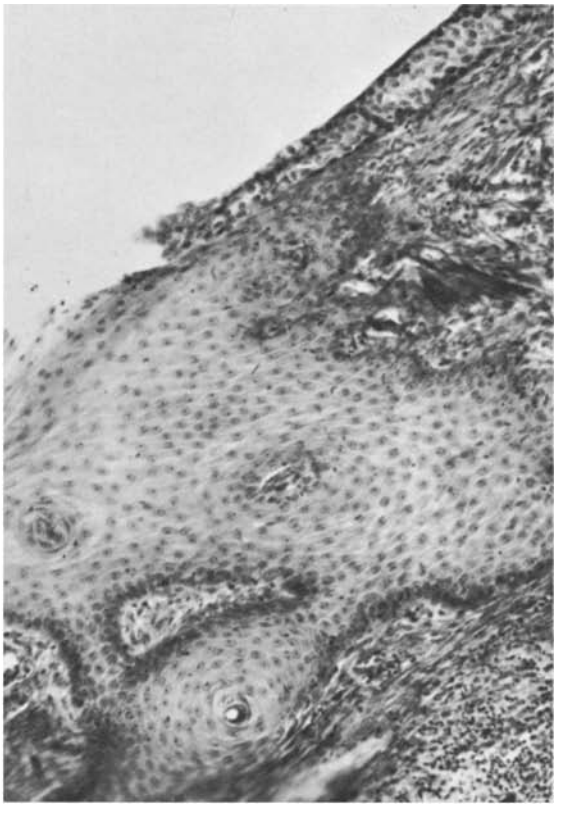

Fig. 3. Transplant-bladder junction 2 weeks postoperatively. v. Gieson

tions besides dryness and roughness of the skin were observed.

Histologically the epidermis of the autograft was somewhat enlarged. The corneal layer was significantly thicker than normal. The hair papillae were degenerate. No effect of the X-rays on the sweat or sebaceous glands was detected. The elastic fibres and collagen appeared normal.

Two weeks postoperatively excretory urography revealed a reduced renal excretion of the contrast medium in comparison with the preoperative urogram in all animals. This finding is in good agreement with the postoperative increase in plasma creatinine, probably due to infection of the urinary tract There was no detectable uretric hold-up and the bladder outline clearly revealed the autograft patch. When subtotal cystectomy had been performed, a typical hour glass constriction of the bladder was observed and attributed to the remaining trigone. Extravasation of contrast medium was not observed.

The histological examination of the pretreated autograft showed fragmentation of the skin texture (Fig. 2). Some degenerated cells of the hair matrix and parts of sweat glands had fragmented nuclear structure. On the lumenal surface shedding of the squamous epithelium had occurred, and infiltration of transitional cell epithelium from the bladder wall had started. In every case, leucocytes were observed around the autograft but no giant cells were seen (Fig. 3).

4-6 weeks postoperatively, excretion urography revealed normal calyces and ureters but the bladder capacity, however, was significantly reduced (Fig. 1). Histologically the autograft was recognized by its tissue structure and by degenerate residual sweat glands. Almost the whole autograft was covered with normal transitional cell epithelium but smooth muscle could not be detected. At the marginal zone a considerable number of capillaries and arterioles were growing in from the normal bladder wall (Fig. 4).

3 months postoperatively, X-ray examination of the bladder showed an almost normal shape and a reduced bladder capacity (Fig. 1).

Macroscopically the autograft could be differentiated by a fine scar around the suture line. The inner surface of the bladder was com-

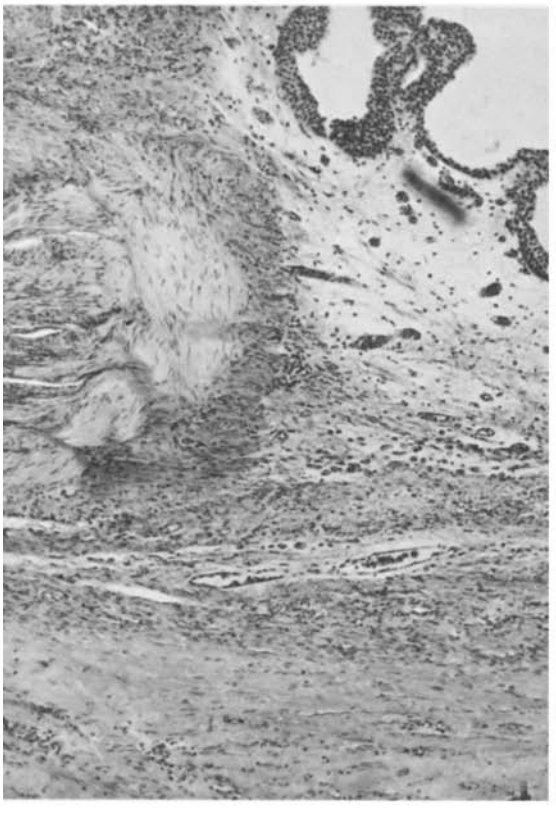

Fig. 4. Transplant-bladder junction 6 weeks postoperatively. v. Gieson

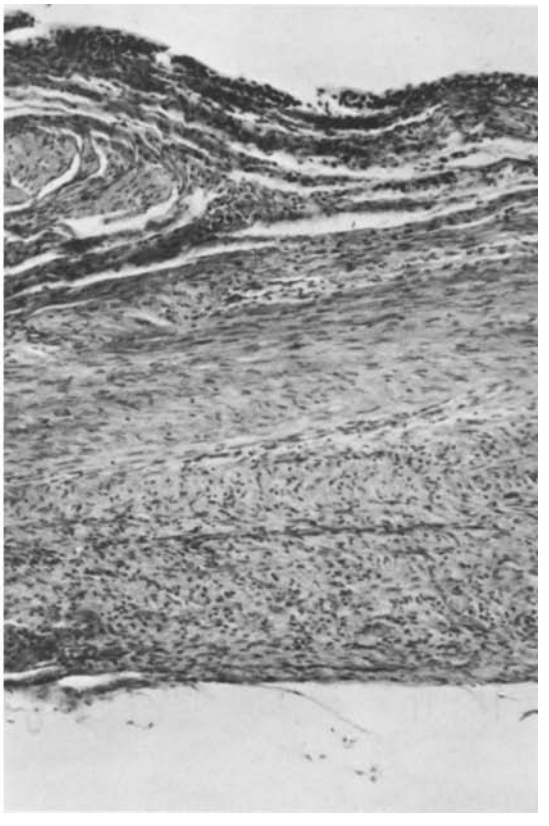

Fig. 5. Transplant-bladder junction 3 months postoperatively. v. Gieson

pletely covered by a normal mucosal layer of transitional epithelium. Histological examination showed thin fibres of smooth muscle in the marginal area of the autograft (Fig. 5). However it was sometimes impossible to differentiate between the vascular muscles of the extensively vascularized autograft and the new muscle of the bladder wall.

6 months postoperatively, the macroscopic and urographic findings demonstrated that the bladder had returned to the preoperative state (Fig. 1).

The transplanted bladder wall was not as thick as the normal bladder wall. The original structure of the corium could still be identified and the regenerated parts of the autograft consisted of dense connective tissue.

Growth of laminar layers of smooth muscle could be positively identified in the marginal zones of the autograft but there was little smooth muscle in its centre. The autograft was well vascularized. The transitional cell epithelium could not be differentiated from the original bladder epithelium (Fig. 6).

1 year postoperatively, excretory urography showed normal renal function and a normal upper urinary tract (Fig. 1). Macroscopically, the transplant could still be identified on the outside of the bladder wall (Fig. 7).

Histological examination revealed that the subepithelial and muscular layers of the autograft were thinner than the normal bladder wall. The normal bladder wall consistently showed a plaited structure of vertically arranged muscles. The autograft was covered by a layer of transitional epithelium of normal thickness (compare Fig. 6).

In animals without the X-ray treatment the autograft was covered on its external surface by a surrounding normal bladder wall, however, the lumenal surface was only partially covered by transitional cell epithelium. Almost in every case the normal unaltered and partially dislodged squamous epithelium could be seen.

Discussion

Epilation of the full thickness skin graft has been found to be essential for covering of the autograft by transitional cell epithelium.

For rapid healing of the full thickness skin transplant, it is imperative that there is a good blood supply to the cut bladder margin. Electrocoagulation should be avoided. Transplantation of the tissue should be accomplished without tension (2, 3, 19). With these precautionary measures normal diffusion of interstitial fluid and vascularisation can be achieved within 2 weeks. The vitality of the autograft can be judged from its red colour.

Another precautionary measure is the early removal of the catheter, thereby reducing the risk of urinary infection. Furthermore, contact with urine and exposure to normal bladder dynamics are essential features for the total regeneration of the bladder wall (4, 5).

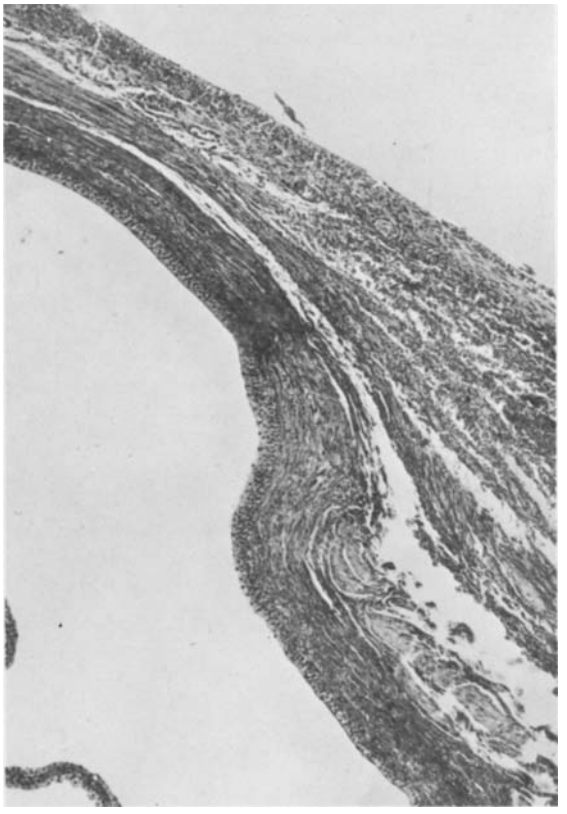

Fig. 6. Transplant-bladder junction 6 months postoperatively. v. Gieson

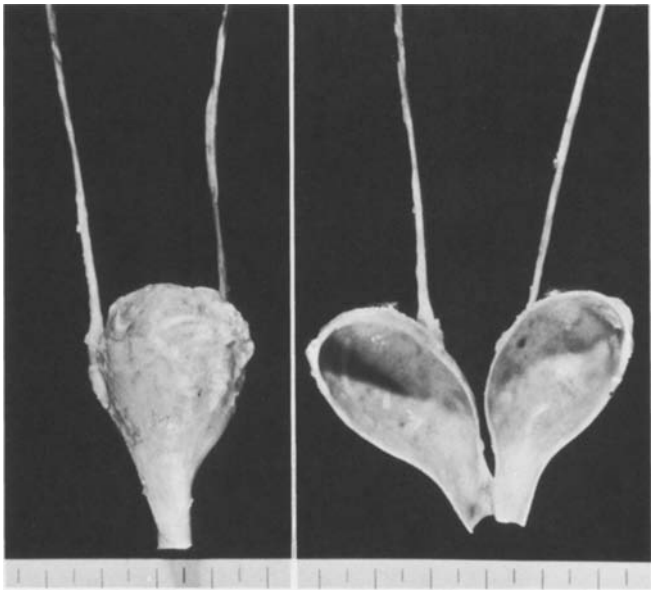

Fig. 7. Macroscopic view of the bladder 1 year postoperatively

The following features indicate the efficacy of this method (1, 4-7, 9, 10, 13, 16-18):

1. Water-tightness of the urinary bladder.
2. Normal bladder capacity
3. No residual urine.
4. Normal upper urinary tract.

Bladder replacement with a full thickness skin graft gives good functional results and represents a further alternative for bladder reconstruction. Different reconstructive material such as fascia, peritoneum, intestine (4, 5, 9, 10, 16) and dura (6, 17, 18) have been tried both clinically and experimentally. However it is not generally accepted that a true bladder replacement is achieved by these materials. The regenerative potency of the remaining bladder is considered to be the essential process of replacement and the reconstructive material is thought to serve only as a morphological guide to bladder growth (10). However we found in the cat that after one year the full thickness graft represents part of the bladder from both a morphological and functional point of view.

The following processes are deemed crucial for the successful function of an autograft:

1. Rapid and complete covering of the internal surface by transitional cell epithelium, thus avoiding reabsorption of urine (4, 5, 9, 10, 14, 16).

2. Muscle growth in the region of the autograft, thereby ensuring the necessary mechanical strength (4, 5, 9, 10, 14).

We conclude that an X-ray treated autologous full thickness skin graft is a satisfactory material for the replacement of large segments of bladder wall. The restoration of normal bladder wall function and the relative simplicity of this method make it feasible for the treatment of various bladder disorders (16, 20).

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