Case series: Surgical success and reproductive performance after correction of penile deviations in 10 bulls

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Abstract

Information regarding expected outcomes such as surgical complications and successful return to natural service after surgery to correct penile deviation of bulls is limited. Therefore, when examining a bull with a penile deviation, making evidence-based recommendations and managing client expectations for return to function is difficult for veterinarians. The objective of the study reported here is to provide documented outcomes of return to reproductive performance for bulls following surgery to correct penile deviation. Medical records at 4 teaching hospitals from 2008 to 2022 were reviewed. Surgical and reproductive outcomes of impotent bulls that underwent surgery to correct spiral or ventral deviation by either fascia graft or synthetic mesh were evaluated. Only 10 cases, from 3 teaching hospitals, had sufficient follow-up information regarding outcome after surgery to be evaluated. None of the bulls experienced surgical complications (e.g., infection, dehiscence, etc.). Surgery sufficiently corrected the deviation to achieve intromission in 6 of the 10 bulls. Five of these 6 bulls sired progeny. Overall, surgical correction of penile deviation in bulls appears to have a low risk for complications, but the success of surgery in returning the bull to reproductive soundness is inconsistent, as only 5 of the 10 total cases sired progeny via natural service.

Key words: penile deviation, bull, fascia lata graft, synthetic mesh graft, surgery

Introduction

Penile deviation in bulls, an occasional cause of intromission failure, may be spiral ("corkscrew"), ventral ("rainbow"), or S-shaped.[1] All 3 types of deviations result from an abnormal dorsal apical ligament, which originates from the distal bend of the sigmoid flexure and inserts just proximal to the glans penis.[2] Proposed etiologies include an abnormal apical ligament, abnormal tunica albuginea, abnormal penile length, and/or altered penile blood flow or erectile pressure. [2] Surgical correction is aimed at forming adhesions between the apical ligament and the tunica albuginea in order to stabilize the position of the ligament.[2,3] Surgical correction of a spiral deviation may be more successful than correction of a ventral deviation,[2] but published data are lacking in regard to the outcomes of bulls undergoing surgery to correct any type of penile deviation. Overall success of the surgery (i.e., correction of the deviation sufficient to allow natural service) is unknown.

One commonly-used method to increase strength of attachment between the apical ligament and the underlying tunica albuginea is autografting.[4-6] This technique is time consuming because it involves harvesting an autologous segment of fascia from a pelvic limb of the bull, which, in turn, necessitates primary closure of the incision and may result in postoperative complications at the site of harvest. Therefore, this technique requires either longer surgery time or a second surgeon for the harvest site. Alternatively, a synthetic mesh, such as one composed of carbon fibers[3,7,8] or dacron-reinforced silicone,[9] can be used in place of the autologous graft. Implanting synthetic material, rather than autologous tissue, speeds surgery and obviates formation of a cutaneous scar on the stifle that accompanies removal of fascia for an autograft. However, synthetic grafts may stimulate a foreign-body reaction causing the implant to be rejected and leading to surgical failure to correct the penile deviation.[3] The outcomes of bulls undergoing implantation of a synthetic mesh graft are lacking in peer-reviewed literature[10] and, anecdotally, surgery performed using a synthetic mesh may have a higher incidence of failure than surgery performed using an autograft.[2]

With such limited information about surgical outcomes and return to reproductive performance, providing evidence-based recommendations and advising owners about the likely outcome of surgery is difficult. The objective of this case series study, therefore, was to determine short- and long-term outcomes of bulls undergoing surgery to corrected penile deviation, both with a graft composed of fascia lata or synthetic mesh.

Materials and methods

Case selection criteria

Electronic databases of medical records of 4 veterinary teaching hospitals were searched for records of bulls that were diagnosed with a penile deviation between 2008 and 2022. The inclusive search terms used included "bull", "deviation", "penis", and "surgery". A total of 28 records were identified. Three cases were excluded due to diagnosis of penile denervation as it was unclear if deviation was a primary condition. Of the remaining 25 bulls (Table 1), 2 bulls did not undergo surgery for economic reasons. Bulls were included in the study if they had been examined for breeding soundness or if the owners were able to provide information about the ability for the bull to breed after surgery, including intromission ability, mating behavior and any observable difficulties during copulation. Only 10 bulls, from 3 of the veterinary teaching hospitals (University of Tennessee, Kansas State University and Iowa State University), had follow-up information whether the bull achieved successful intromission (n = 10), the number of pregnancies conceived via natural service post-surgery (n = 10), post-surgical complications (n = 10), and the owner's satisfaction with the surgical outcome (n = 9) to be reported in the study (Table 2).

Medical record review

For each bull enrolled in the study, comprehensive data were obtained from the medical record. These data included breed, age and weight at presentation, the method by which the deviation was diagnosed, presumed duration of deviation, type of deviation (spiral or ventral), intended use of the bull (natural breeding or artificial insemination), type of anesthesia

Table 1: Descriptive information of bulls (n = 25) diagnosed with penile deviation at 4 veterinary hospitals (2008-2022).

Hospital	Bull ID	Breed	Age at presentation (years)	Deviation type	
				Spiral	Ventral
University of Tennessee	A	Black Aberdeen-Angus	4	x	
	B	Black Aberdeen-Angus	5		x
	C	Black Aberdeen-Angus	3		x
	D	Simmental	3	x	
Kansas State University	E	Black Aberdeen-Angus	5	x	
	F	Black Aberdeen-Angus	3	x	
	G	Black Aberdeen-Angus	3		x
	H	Black Aberdeen-Angus	5	x	
	I	Horned Hereford	4	x	
	J	Simmental Cross	6	x	
Iowa State University	K	Black Aberdeen-Angus	3	x	
	L	Black Aberdeen-Angus	6		x
	M	Maine Anjou	3	x	
	N	Maine Anjou	5		x
	O	Mixed Breed Beef	1	x	
	P	Mixed Breed Beef	4		x
	Q	Red Angus	5	x	
	R	Red Angus	6	x	
	S	Red Angus	4	x	
	T	Red Angus	4	x	
	U	Red Angus	5	x	
	V	Red Angus	5		x
	W	Shorthorn	3	x	
Auburn University	X	Black Aberdeen-Angus	4		x
	Y	Brangus	3		x
	n = 25		*Median = 4*	*n = 16*	*n = 9*

Table 2: Descriptive information for bulls (n = 10) for which follow-up information was available on surgical and reproductive success (2008-2022).

Bull ID	Deviation type	Breed	Age (years)*	Surgical type	Surgical success	Reproductive success
A	Spiral	Black Aberdeen-Angus	4	Synthetic mesh	Yes	Yes
B	Ventral	Black Aberdeen-Angus	5	Synthetic mesh	No	No
C	Ventral	Black Aberdeen-Angus	3	Synthetic mesh	Yes	NA†
D	Spiral	Simmental	3	Synthetic mesh	No	No
E	Spiral	Black Aberdeen-Angus	5	Autologous *fascia lata*	Yes	Yes
S	Spiral	Red Angus	4	Synthetic mesh	Yes	Yes
T	Spiral	Red Angus	4	Synthetic mesh	Yes	No
U	Spiral	Red Angus	5	Synthetic mesh	Yes	Yes
V	Ventral	Red Angus	5	Synthetic mesh	Yes	Yes
W	Spiral	Shorthorn	3	Synthetic mesh	No‡	No

* Age at presentation.

† Not available due to death of the owner and sale of the herd. NA = not applicable.

‡ Postoperatively, Bull W's spiral deviation was corrected, however his penis deviated ventrally.

used (general anesthesia or sedation), surgical approach, type and size of suture material used, and type of graft implanted (synthetic mesh or autograft). Postoperative factors examined included postoperative medical management (including drugs and preputial bandaging), duration of hospitalization, post-surgical complications that occurred prior to follow-up, sexual rest period after surgery, results of a breeding soundness examination performed at least 60 days after surgery, and if intromission occurred. For bulls which intromission occurred, an estimation of the number of cows that conceived via natural service by the bull after surgery.

The outcome of the surgery was obtained by performing a breeding soundness examination at least 60 days after surgery or a phone interview with the owner at least 1 year postoperatively. The surgery was considered successful if the penis appeared to no longer deviate to a degree that would prohibit intromission during natural service. This gross observation involved a visual and physical examination of the penis, assessing its straightness and alignment at a breeding soundness examination or was verified by owner observation of successful copulation. Reproductive success was defined as the ability of the bull to produce a pregnancy in 1 or more cows via natural service after surgery. During the phone interview at least 1 year postoperatively, owner's satisfaction with the surgery was considered positive if the owner would request the surgery to be performed again on another similarly affected bull, or negative if the owner would choose to cull another similarly affected bull of the same value.

Results

Signalment

Of the 25 cases of penile deviation that underwent surgical correction, post-surgical information was available for only 10 bulls (Table 2). Age at the time of presentation, ranged from 1 to 6 years old with a median of 4 years and interquartile range (IQR) of 1.75 years. Precise weight at the time of presentation was only recorded for 8 bulls, and the weight of these 8 bulls ranged from 1,646 to 2,328 lbs. (816 to 1,055 kg).

Clinical signs and examination

All 10 bulls appeared to be healthy during physical exam. No irregularities were found during the examination of their internal genitalia or testes. The diagnosis of penile deviation was established based on the breeding history of the bulls (e.g., acquired condition preventing intromission), the observations of the owner and/or bull stud facility personnel, and the results of examination of the penis exposed using an electroejaculator. Seven bulls had a spiral deviation, and 3 bulls had a ventral deviation. No bulls had an S-shaped deviation.

Pre-surgical medication and anesthetic protocols

Once, prior to on the day of surgery, all bulls received ceftiofur crystalline free acid (6.6 mg/kg SC) or a combination of penicillin G procaine (30,000 to 66,000 units/kg, IM) and oxytetracycline (15 mg/kg SC). Bulls were also administered flunixin meglumine (1.1 mg/kg IV).

The 10 bulls included in the study were maintained under general anesthesia; however, it is worth noting that this procedure has been performed under local anesthesia utilizing a pudendal block and sedation on a tilt table

Surgical procedure

Bulls were placed in right lateral or dorsal recumbency and hair on the abdomen and prepuce clipped. The bull was prepared for aseptic surgery by scrubbing the abdomen and prepuce with an antiseptic soap, and the abdomen and prepuce were covered with drapes. The penis and internal lamina of prepuce were extended, and a towel clamp was placed beneath the cranioventral aspect of the distal apical ligament to keep the penis extended during surgery.

A skin incision ranging from 12 to 20 cm was made using a #10 blade on midline along the dorsum of the penis beginning just caudal to the glans penis. The incision was deepened through the thin fascial layer and through the loose elastic layers in the preputial portion of the incision to expose the apical ligament. A #10 blade was then used to split the apical ligament longitudinally, and Metzenbaum scissors were used to bluntly dissect the tissue as needed. The 2 halves were reflected laterally to expose the tunica albuginea of the penis. The 2 dorsal veins that drain the corpus spongiosum of the penis were carefully avoided.

Bulls either underwent repair with a synthetic mesh (n = 9) composed of expanded polytetrafluoroethylene (ePTFE), which the surgeon may or may not have been soaked in a solution of isotonic saline solution and lincomycin hydrochloride or an autograft of fascia lata harvested and prepared, as described by Wolfe et al.[2] (n = 1) prior to exposing the apical ligament. Either the mesh or fascia lata graft was placed on the tunica albuginea under the apical ligament as far proximally as possible. Care was taken to position the graft so that it laid flat on the tunica albuginea. The graft was secured/sutured to the tunica albuginea using multiple simple interrupted or cruciate sutures of synthetic absorbable material (Polydioxanone II [PDS] 3-0) 5 mm to 1 cm apart. Care was taken to avoid completely penetrating the entire thickness of the tunica albuginea, and once the graft was securely in place, the apical ligament incision was closed and the ligament tacked down to the graft using 2-0 PDS suture in a simple continuous pattern. After the apical ligament was properly closed, the incision was thoroughly rinsed with isotonic saline and cleaned before closing the skin layer. The skin layer was closed using 2-0 absorbable suture material in either a horizontal mattress, cruciate or intradermal suture patterns. Centripetal alternate suture placement from the distal and proximal ends of the incision were used for interrupted suture patterns.

A lanolin-based ointment containing oxytetracycline was applied to the internal lamina of the prepuce, and the towel clamp was removed, allowing the penis to retract into the preputial cavity. Depending on the surgeon, in 5 cases a rigid, fenestrated tube was inserted into the preputial cavity so that the proximal end of the tube covered the tip of the penis. The tube was secured to the penis with an elastic adhesive bandage, which was secured to the external lamina of the prepuce with an interrupted skin suture inserted on each side of the external lamina. Extralabel drug use complied with provisions of AMDUCA and 21 CFR 530 and was performed with owner consent.

Postoperative treatment

Antimicrobial therapy was continued after surgery for at least 4 days and consisted of long-acting oxytetracycline (15 mg/kg SQ once) or long-acting ceftiofur crystalline free acid (6.6 mg/kg SC once) or a combination of both. Flunixin meglumine (1.1 mg/kg IV every 12 hours) or meloxicam (0.5 mg/kg PO every 24 hours) was administered for 1 to 12 days after surgery. Bulls were discharged from the veterinary hospital between 10 and 18 days after surgery. Bulls were allowed 2 to 9 months of sexual rest to allow for complete healing and recovery.

Surgical and reproductive outcomes

Surgical outcomes were determined via either a test mating performed 2 months postoperatively by bull stud personnel (n = 4, bulls S, T, U and V) or surgeon (n = 1, Bull W), a breeding soundness exam 3.5 months postoperatively (n = 1, Bull C), or a phone interview with the owner at least 1 year postoperatively (n = 4, bulls A, B, D and E). Reproductive outcomes were determined via a phone interview with the owner at least 1 year postoperatively. In the case of Bull C, information about intromission was obtained via a phone interview at 4 months postoperatively, but estimation of the number of cows bred and resulting pregnancies were unable to be obtained at a later date due to death of the owner.

At the time of follow-up, no surgical complications (i.e., infection, dehiscence, etc.) were reported in any of the cases. A total of 7/10 (70.0%) of deviations were corrected following surgery (i.e., considered a surgical success, Table 2). Of the bulls in which surgery was not successful, 1 had a ventral deviation and 2 had a spiral deviation. Notably, the owner of Bull W stated the spiral deviation appeared to be corrected on breeding soundness examination, however the bull was unable to achieve intromission when placed with cows likely due to ventral deviation or penile denervation, as reported by the referring veterinarian. However, postoperatively this bull was successfully collected for fresh and frozen insemination between the 60-day sexual rest period and the phone interview follow-up at 17 months postoperatively.

Pregnancies conceived via natural service post-surgery were reported in 5/7 (71.4%) cases in which surgery was successful (bulls A, E, S and U) for a total "reproductive success" of 5/10 (50%, Table 2). Per the owners, all bulls were in single-sire breeding groups except for Bull E (Table 3). While that information was unavailable for Bull E, at the follow-up phone interview 10 years postoperatively, the owner of Bull E was confident that he was successfully siring pregnancies as he was kept as a breeding bull for more than one season. Because this condition is not known to affect semen quality, and stress effects around surgery are transient, it is likely that because intromission occurred, pregnancies resulted, and therefore this bull was considered a success. Bulls remained in the breeding herd for up to 3 years (Table 3). For bulls in which information was available, each bull was estimated to have bred at least 30 cows in which ≥ 90% became pregnant per season (Table 3).

There was one bull (Bull C) for which surgical success was determined by owner observation of successful intromission but further follow-up regarding pregnancy confirmation and general satisfaction was lost due to death of the owner and sale of the herd. Therefore, 6 of the 7 bulls for which surgery was considered to be successful were able to achieve intromission. The other bull weighed more than 2,400 lbs. (1,091 kgs, Bull T) and was observed to have the penis adequately straightened but was unable to achieve intromission, which was attributed to the inability of heifers in estrus to remain standing under his weight.

All owners except that of Bull C, who passed away before this question could be asked, stated that they would have the surgery performed on a future bull if they had a valuable bull that was impotent because of a penile deviation.

Discussion

This study aimed to describe the surgical and reproductive outcomes of 10 bulls with a penile deviation that underwent surgical correction of the deviation using synthetic mesh or autologous fascia lata graft. The results of the study show that penile deviation in bulls may be surgically corrected, with low risk of surgical complications. Six of the 7 bulls for which

Table 3: Owner described reproductive outcomes bulls (n = 10) for which surgery was reproductively successful (2008-2022).

Bull ID	Deviation type	Longevity in the breeding herd *	Single or multi-sire pasture	Estimated number of cows bred per season	Estimated pregnancy rate (%) per breeding season
A	Spiral	1+ years	Single	N/A†	N/A†
E	Spiral	2 to 3 seasons	N/A†	40-50	N/A†
S	Spiral	3 years	Single	30	90-95
U	Spiral	2 years (4 seasons)	Single	30	90-95
V	Ventral	1 year (2 seasons)	Single	30	90

* A plus indicates the bull was still in the herd at time of follow-up.

† Owner did not provide this information.

surgery was considered to be successful were able to achieve intromission. In 5 of these 7 bulls, pregnancies resulting from intromission were reported.

Spiral ("corkscrew") penile deviation, the most common penile deviation,[3] occurs when the apical ligament slips from its normal site on the dorsal surface of the penis to the left side of the penis.[11] Proposed etiologies for spiral deviations include a short dorsal apical ligament which becomes displaced during erection and/or premature achievement of peak erectile pressure prior to intromission resulting in spiraling of the penis.[2] The mean prevalence of spiral deviation is reported to be 10%, however this varied significantly in polled breeds (16%) versus horned Hereford bulls (1%).[12] In this case series, spiral deviation (16/25, 64%) was the most common type of deviation. A ventral ("rainbow") deviation is thought to result from an abnormal tunica albuginea or apical ligament combined with altered blood flow. [2] An S-shaped deviation may be due to inadequate apical function caused by a mismatch between apical ligament length and penile length.[2] Prevalence for ventral and S-shaped deviations have not been reported. In this case series, ventral deviations were diagnosed in over one-third of cases (9/25, 36%). None of the 25 bulls diagnosed with a deviation have an S-shaped deviation.

Of all 25 bulls diagnosed with a deviation, 10 were Aberdeen Angus (50%) and 6 were Red Angus (30%). The high proportion of these breeds in the study population likely reflects the popularity of the breeds, but a larger study population would have been necessary to determine if either breeds are predisposed to developing a penile deviation. Prevalence of spiral deviation may be higher in polled breeds.[11] Although horned status was not listed in the medical records for most cases, many of the cases were breeds that are traditionally polled (e.g. Angus). Interestingly, 3 Red Angus bulls (n = 2 spiral deviations and n = 1 ventral deviation) were from the same owner. Although pedigree analysis in one study suggested spiral deviation was likely heritable, it is not thought to be associated with the polled gene.[11] Pedigree analyses are lacking for other deviation types. Five additional beef breeds, including a *Bos indicus* X *Bos taurus* cross, were represented in bulls diagnosed with penile deviation throughout the 4 hospitals. Dairy breeds were not represented. This may be due to the high rate of artificial insemination in the dairy industry, which reduces the number of bulls used for natural service. It may also reflect the population of the case load that presents to teaching hospitals in the current study and/or the perceived value of certain breeds.

Sexual rest was recommended after penile surgery to allow for proper healing thereby reducing the risk of complications. Bulls in this case series had 2 to 9 months of sexual rest following surgery. The length of time the bulls were sexually rested in this study was similar to that recommended by others.[1,2,6] In this study, the absence of complications in all cases may be due in part to the adequate rest period after surgery.

Although the majority (7/10, 70%) of the bulls that underwent surgery in this study had a successful surgical outcome, surgery failed to resolve the penile deviation of 3 bulls (30%). Unfortunately, the causes of the failure remain unidentified. Possible explanations for surgical failure could include incorrect graft length, failure of the graft to adhere properly to the tunica albuginea, individual differences in the severity of the deviation, and failure to provide proper post-surgical care. Additionally, penile denervation may be a possible underlying etiology. In one report, a bull with spiral penile deviation was found to suffer from denervation of the penis, and this denervation was proposed to be the cause of the deviation. This bull did not undergo surgery to correct the deviation due to the presumption that he would never return to natural service because of the denervation.[13] Notably, 2 additional cases presenting for spiral deviation that were confirmed to have denervation were identified during medical record review. In our study, 2 of the 3 bulls that experienced surgical failure had a spiral deviation, and it is possible that failure of surgery to correct the deviation could have been because the penis was denervated either before, during or after the surgery. If this hypothesis is supported, nerve conduction testing prior to surgical correction may improve case selection for surgery and subsequently improve the probability of a successful outcome. Bulls with corpus cavernosum filling defects or vascular shunts[2] may present similarly to those with ventral deviations. A contrast cavernosography could be recommended to rule out these conditions prior to surgery. Further research identifying potential predictors of surgical success in bulls with penile deviations would allow for stronger evidence-based recommendations when veterinarians are assessing a bull with penile deviation.

An additional explanation for surgical failure could be due to the method used to diagnose the deviation. The gold standard to diagnose deviation is through repeated observation during test mating.[2,6] For this study, penile deviation was diagnosed, in part, by using electroejaculation to expose the penis. Electroejaculation itself can result in spiraling of the penis in bulls that do not have a deviation observable during natural

mating.[14] In the current study, owner's observations and provided history, along with examination of the penis, were critical for the attending veterinarian to recommend surgery when using electroejaculation for penile exposure. In this study, 3 of the 5 cases diagnosed via electroejaculation and owner observations (i.e., not with test mating) were successfully corrected after surgery. Overall, a misdiagnosis resulting from either lack of test mating or concurrent denervation or shunt cannot be ruled out in the 3 cases of surgical failure.

No comparison of the surgical graft was performed in this study as only 1 bull had a fascia lata graft implanted. The expanded polytetrafluoroethylene artificial graft was well tolerated by the bulls and no foreign body reactions were observed. This surgical technique seems to compare favorably to the fascia lata autograft technique and has the great advantage of significantly reducing the surgery/anesthesia time and avoiding the morbidity of the donor site.

Owners reported 6 of the 7 cases of surgical success (i.e., deviation appeared corrected postoperatively) achieved intromission post-surgery. Reproductive success, defined as 1 or more reported pregnancies from the bull, after surgery, was positive in 5 out of these 7 cases. Although this sample size is small, it is encouraging that one bull (Bull E) was reported to have bred 40 to 50 cows after surgery and stayed as a member of the herd for at least 2 breeding seasons. Three other bulls (bulls U, S and V) each bred ~30 cows per season with a > 90% pregnancy rate for 2 to 4 seasons. This indicates that surgical correction of penile deviations may be expected to result in reproductive success for more than one season. Based on responses to the survey, owners may be reasonably satisfied with selecting surgical correction for valuable bulls that present for penile deviation if they are informed of the variability in success but low rate of complications.

The major limitation of the current study was the small sample size, particularly when considering that 2 types of penile deviation were included. This likely reflects both the frequency in which the procedure is performed and the need for long-term follow up. Complete follow-up to assess outcomes was available only for 9 out of 23 bulls (39%) that underwent surgical correction. The follow-up period varied greatly between bulls, with 1 bull having a follow-up of only 4 months, whereas the others had a follow-up of 1 to 10 years. This could have impacted reported outcomes. Other factors that may have contributed to variation in outcomes includes differing ages, breeds, surgeons, hospitals, graft type, postoperative management and other unknown factors. Despite these limitations and because of the lack of published studies, the case series presented here provides valuable insights into the surgical and reproductive outcomes of bulls undergoing surgery to correct a penile deviation.

Overall, the economic value of the bull based on genomics, pedigree and ease of replacement with another bull will likely determine if the owners would like to pursue surgical correction. Although cases described herein are from referral institutions, this surgery could be performed under local anesthesia with restraint on a tilt table by a private practitioner who has an understanding of the surgical anatomy and general surgery expertise. Overall, findings of this study suggest that conservatively half of the bulls undergoing surgery will eventually sire progeny. Because no surgical complications were found, it is likely that the owner would still be able to recuperate the cull value of the bull when surgery is unsuccessful.

Conclusion

The objective of this study was to describe the surgical and reproductive outcomes of bulls that underwent surgery to resolve penile deviation. Surgery to resolve penile deviation was performed using a synthetic mesh or autologous fascia lata graft. Surgery of 7 of 10 bulls (70%) was considered a surgical success and no bull (0%) experienced surgical complications. Five bulls (50%) were reported to sire progeny after surgery via natural service. This study shows that surgical correction is a safe and moderately effective option for treating penile deviations in bulls.

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Conflict of Interest

None to declare.

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