Complete and partial hoof wall resection for keratoma removal: post operative complications and final outcome in 26 horses (1994–2004)

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Summary

***Reasons for performing study*: There are no data on the frequency of post operative complications following keratoma removal, such as recurrence, hoof wall instability and excessive granulation tissue formation, or their relation to the method of surgical removal.**

***Objective*: To identify important factors in the outcome for horses undergoing surgical removal of a keratoma and compare the post operative complications encountered following keratoma removal by complete hoof wall resection (CR) and partial hoof wall resection (PR).**

***Hypothesis*: Horses undergoing PR would have fewer post operative complications and would return to work more quickly than those undergoing CR.**

***Methods*: A retrospective review of medical records from one equine hospital identified 26 horses that underwent removal of a keratoma by CR or PR. Clinical, radiological and surgical findings and outcome were analysed.**

***Results*: Common clinical signs included lameness and the presence of a subsolar abscess. Fourteen horses underwent CR and 12 PR. The complication rate following CR (71%) was significantly lower than that following PR (25%) ($P<0.01$). Complications encountered included excess granulation tissue formation, hoof crack formation and keratoma recurrence at the surgical site. The time taken to return to full work post operatively was significantly shorter in horses undergoing PR compared to CR ($P<0.01$). All horses, except one, returned to their previous exercise level.**

***Conclusions*: PR resulted in fewer post operative complications and a more rapid return to athletic activity than CR.**

***Potential relevance*: Although the overall complication rate for CR was higher than for PR, the overall prognosis for return to soundness and the previous performance level is very good.**

Introduction

Keratomas are aberrant, hyperplastic, keratin masses and are a rare cause of lameness in the horse (Lloyd *et al.* 1988). They normally arise from the epidermal keratin-producing cells of the *stratum germinativum* of the coronary band (Reeves *et al.* 1989; Hamir *et al.* 1992), but can also originate from any point on the inner surface of the hoof wall or from the sole (Lloyd *et al.* 1988; O'Grady and Horne 2001). Keratomas are interposed between the *stratum medium* of the hoof wall and the underlying distal phalanx (Honnas *et al.* 1988; Chaffin *et al.* 1989; O'Grady and Horne 2001). Complete surgical excision can result in resolution of the lameness (Wagner *et al.* 1986). Two surgical techniques have been reported; complete hoof wall resection (CR) from the coronary band to the sole and partial wall resection (PR) directly over the mass (Honnas 1997). Complications such as keratoma recurrence, hoof wall instability and excessive granulation tissue formation have been reported (Helms *et al.* 1994), but there is no data on the frequency of these complications and their relation to the method of surgical removal.

This study aimed to identify the common presenting signs of keratomas and important factors in the outcome for horses undergoing surgical removal of a keratoma. It was hypothesised that horses undergoing PR would have fewer post operative complications and would return to work more quickly than those undergoing CR.

Materials and methods

The medical records of 26 horses diagnosed with a keratoma at the University of Liverpool (1994–2004) were reviewed. Data examined included subject details, history, clinical signs, radiological findings, surgical technique, post operative treatment, complications and outcome. Follow-up information was obtained by telephone questionnaire with owners. Complete data from 26 horses were available.

Radiographical analysis

Lateromedial, horizontal dorsopalmar/plantar, dorso60ºproximo-palmaro/plantarodistal oblique (DPrPDiO) (centred on the distal phalanx), dorso45ºlatero60ºproximo-palmaro/plantaromediodistal oblique (DLPrPMDiO) (Fig 1) and dorso45ºmedio60ºproximo-palmaro/plantarolaterodistal oblique (DMPrPLDiO) radiographs were obtained (Butler *et al.* 2000) using a Polydorus 80 x-ray unit[1]. The lateromedial and the DPrPDiO views were repeated with a metal probe inserted into the draining tract. This allowed the most

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proximal extent and the direction of the tract to be determined. In cases where the tract did not extend as far proximally as the coronary band, a hoof knife was used to resect a small section of hoof wall at the most proximally identified extent of the tract so that the location could then be determined intraoperatively.

Choice of surgical procedures

The choice of surgical technique used as described below was not randomised but was determined by the surgeon based on the most proximal extent of the abnormal tract that had been determined radiographically using the metal probe. Partial resection was performed in cases where the tract was not identified to extend to the coronary band, and complete resection in cases where the tract extended to the coronary band.

Surgical procedures

The affected foot was trimmed, rasped, scrubbed and wrapped in a povidine iodine (Pevidine Antiseptic Solution)[2] dressing 24 h before surgery. Preoperative therapy included 15 mg/kg bwt i.m. neomycin penicillin (Neopen)[3] and 4.4 mg/kg bwt i.v. phenylbutazone (Equipalazone)[4]. Neomycin penicillin i.m. was continued for 3–5 days and phenylbutazone *per os* for 1–2 weeks at a decreasing dose, depending upon clinical comfort. Surgery was performed under general anaesthesia, in lateral recumbency with the affected side of the foot uppermost. The foot was prepared aseptically. Medial and lateral palmar/plantar nerve blocks at the level of the proximal sesamoid bones were performed using 3 ml 0.5% bupivacaine hydrochloride (Marcain)[5] for each nerve prior to the placement of an Esmarch's tourniquet. The keratomas were removed via hoof wall resection.

Complete hoof wall resection

A sterile metal probe was inserted into the solar drainage tract to determine the direction and proximal extent of the abnormal tissue. Two parallel vertical cuts were made using a cast-cutting saw on either side of the abnormal tissue. The cuts were connected distally along the white line and a second horizontal cut was then made proximal to the abnormal tissue, just distal to the coronary band (Fig 2). All cuts were made to the level of the sensitive laminae. The hoof wall was grasped distally and levered towards the coronary band using a chisel, exposing the keratoma and allowing surgical excision. The surgical site was checked carefully to ensure that the proximal and distal extents of the keratoma had been removed. Debridement of any necrotic dermal or epidermal tissue was performed to the level of healthy tissue. The suspected keratoma and surrounding tissue was submitted for histopathology. The degree of tissue removal was based on visual assessment of the surgical site.

Partial hoof wall resection

Accurate anatomical definition of the affected area was obtained radiographically preoperatively using a metal probe. A cast saw or a 2 cm trephine was used to create a 'window' in the hoof wall centred over the marked section of hoof wall that had been made preoperatively at the proximal extent of the abnormal tract (Fig 3a). In some cases, either this 'window' had to be enlarged intraoperatively (Fig 3b) or a second 'window' had to be made through the sole to ensure removal of all the abnormal tissue, based on the visual assessment of the surgical site. However, a 2 cm bridge of distal hoof wall was maintained in all cases. The keratoma and surrounding tissue were removed and submitted for histopathology.

Fig 1: Dorso45ºlateral60ºproximo-plantaromedial distal oblique radiograph of the distal phalanx of Case 8*. There is a semicircular, well circumscribed radiolucency on the palmarolateral aspect of the distal phalanx. There is no surrounding bone sclerosis.*

Histopathology

The removed tissue was fixed in 10% buffered formalin[6] and underwent routine histopathological processing prior to staining with haematoxylin and eosin. Transverse 5 µm sections were made.

Post operative care

A foot bandage was applied at surgery and was changed every 3 or 4 days when the surgical site was cleaned and repacked with swabs. The swabs were soaked in either gentamicin sulphate (Pangram)[7] or metronidazole (Marcoflex)[8] to decrease the risk of post operative infection until the defect contained healthy granulation tissue. A normal shoe with side clips placed at the widest aspect of the hoof, or a hospital plate bolted to a heart bar shoe, was applied once the defect was dry and demonstrated signs of keratinisation (3–30 days post operatively). The shoe was reset every 4–5 weeks. A metal 'bridging' plate applied across the hoof defect on the dorsal hoof wall was used in cases where there was significant hoof wall instability caused by the removal of a wide section of hoof wall. The plate was fixed to the hoof wall using polymethylmethacrylate (PMMA; Equilox)[9] (Fig 4). Following farriery, the hoof defect was inspected and cleaned every 3 or 4 days. Once the tissue in the defect was keratinised, the area was filled with PMMA in all cases. Hoof defect preparation consisted of removal of any loose horn, cleaning and debridement of the defect, warming the hoof wall with a hair-dryer and degreasing the defect with acetone before the application of the PMMA. A normal shoe with quarter or side clips, depending upon the location of the hoof wall defect, was then fitted. Once filled, controlled exercise was initiated, commencing with hand-walking and increasing gradually depending upon soundness and hoof wall stability.

Fig 2: Complete hoof wall resection (CR) in Case 2 *allowing removal of the keratoma. Two parallel vertical cuts have been made in the lateral aspect of the hoof wall, either side of the abnormal tissue, using a cast saw. These have been connected with two horizontal cuts, one at the level of the white line and the second just distal to the coronary band. The keratoma remained attached to the hoof wall when it was removed.*

Statistical analysis

All variables were screened using a Fisher's exact test ($P<0.01$) to determine important factors in post operative outcome and to compare CR and PR. Variables analysed included age, sex, breed, use, limb affected, duration of lameness, history, surgical technique, complications encountered and time taken for the hoof defect to grow out. Details regarding the actual size of the keratoma and the exact size of the removed section of hoof wall were not available. A Mann-Whitney U test ($P<0.01$) was performed to determine whether the time to soundness and resumption of normal exercise was significantly different following CR and PR and whether there was a delay in return to work in horses suffering from post operative complications.

Results

History and clinical findings

The 26 horses included in this study included 18 Thoroughbreds or Thoroughbred-crosses, 4 ponies and 4 animals of various breeds, aged 2–20 years (mean 10.3 years). Fifteen horses were geldings, 9 mares and 2 stallions. Only one foot was affected in each case. Seventeen cases involved the front foot and 9 the hind foot. Duration of lameness prior to referral was 2 weeks to 9 months (mean 3.2 months). The degree of lameness at the time of presentation varied from 1–8/10 (mean 3/10) at the trot (Ross 2003). Twenty-two (85%) horses had a history of a subsolar abscess, recurrent in 17 cases. Three (12%) horses presented with abnormal tissue visible at the white line. Five (19%) horses presented with a hoof wall deformity and one (4%) with deviation of the white line. Three (12%) horses did not have any localising clinical signs. All horses presented with lameness attributable to the keratoma except *Case 6*, in which lameness was localised to the tarsometatarsal and centrodistal

Fig 3a: Partial hoof wall resection in Case 18. *A 'window' was created in the hoof wall using a cast saw, maintaining a bridge of hoof wall distally. The depression made by the keratoma can be seen as a triangular area in the centre of the hoof defect (arrow).*

Fig 3b: Partial hoof wall resection in Case 21. *A 'window' was created in the hoof wall using a cast saw, then extended proximally intraoperatively to just distal to the coronary band in order to facilitate removal of the keratoma. A bridge of hoof wall was maintained distally.*

*Fig 4: A metal plate has been fixed with polymethylmethacrylate to the dorsal hoof wall across the defect to increase the stability of the hoof wall (*Case 12*). The keratoma had been removed following complete hoof wall resection.*

joints and treatment for this condition was underway. This horse had abnormal tissue present at the white line and a well-circumscribed, semicircular radiolucency on the solar margin of the distal phalanx. The owner elected for keratoma removal despite the lack of clinical lameness related to this condition. Three horses had undergone previous surgical debridement (with minimal wall resection) prior to referral without detection of the keratomas.

Radiological findings

All lesions consisted of a distinct, smoothly outlined semi-circular radiolucent area on the solar margin of the distal phalanx (Fig 4). There was evidence of bone sclerosis surrounding the radiolucent area in 6 horses. There was irregular new bone formation on the dorsal aspect of the distal phalanx in 2 horses. The size of the radiolucent area was not measured as no markers had been used at the time of radiography to correct for magnification. Twenty of the keratomas were located at the toe or quarter. There were no radiological abnormalities in *Case 5*.

Surgical findings

Complete hoof wall resection was performed in 14 horses and PR in 12 horses. The keratoma extended to the coronary band in 20 cases, 14 of which were treated by CR. The remaining 6 cases were treated by PR as the tract that had been probed preoperatively did not extend to the coronary band. However, visual assessment at the time of surgery in these cases demonstrated that the keratoma tissue extended further proximally than the tract. Keratoma removal in these cases was facilitated by proximal extension of the hoof wall 'window' to just distal to the coronary band (Fig 3b). The keratoma was present between the coronary band and the white line in 5 cases and was located only at the sole in one case. These 6 cases were all treated by PR. In 10 cases treated by PR, a trephine hole was also made in the solar surface to aid keratoma removal at the distal aspect of the hoof wall, while still maintaining a distal bridge of hoof wall. Keratoma removal always resulted in a defect in the outer dermal layers of the laminae.

Gross pathological features

The keratoma was a discrete cone-shaped or cylindrical structure with a grey/brown shell-like appearance in 14 cases. In the remaining cases, the original form of the keratoma had been lost due to surrounding tissue necrosis, infection or previous veterinary intervention. Where the keratoma was discrete in structure, complete removal was easy to determine. Where tissue necrosis or infection was present, removal of all visible abnormal tissue was performed to increase the likelihood of complete keratoma removal.

Histopathology

Histology confirmed the presence of a keratoma in all horses. Consistent histological findings included markedly hyperplastic, hyperkeratotic stratified squamous epithelium and rete peg formation from the epithelium into the underlying fibroblastic connective tissue. Neutrophils, lymphocytes, plasma cells and macrophages were present within the connective tissue in the majority of cases. Focal bacterial colonisation was seen in 4 cases.

TABLE 1: Surgical technique used, convalescence time and post operative complications encountered

Horse	Surgical technique	Complications	Sound	Exercise
1	CR	GT	7	9
2	CR	None	4	8
3	CR	GT	3	11
4	CR	GT, HD	3	6
5	CR	GT	7	10
6	CR	GT, SSA	Eu	Eu
7	CR	None	1	12
8	CR	None	12	14
9	CR	GT	6	10
10	CR	Recurrence	8	10
11	CR	None	5	10
12	CR	GT	6	8
13	CR	HCc	30	36
14	CR	HCp	12	18
15	PR	None	5	6
16	PR	GT	6	10
17	PR	Recurrence	4	6
18	PR	None	3	6
19	PR	None	4	7
20	PR	None	5	7
21	PR	None	3	6
22	PR	Recurrence	5	7
23	PR	None	5	8
24	PR	None	4	7
25	PR	None	4	6
26	PR	None	5	8

Sound = Months post operatively when sound at trot; Exercise = months post operatively when previous exercise level was attained; CR = complete hoof wall resection; PR = partial hoof wall resection; GT = excess granulation tissue formation at the surgical site; HD = hoof defect remaining at time of follow-up; SSA = subsolar abscess; HCc = complete hoof crack; HCp = partial hoof crack; Eu = subjected to euthanasia for reasons related to the keratoma.

Post operative care

Post operatively, the swabs used to pack the hoof wall defect were soaked in gentamicin sulphate (Pangram)[7] in 6 cases and metronidazole (Marcoflex)[8] in 20 cases. The bolted-on hospital plate was used in all cases undergoing CR and in the 10 cases undergoing PR, in which a solar trephine hole was also created. In the 2 remaining cases treated by PR, a normal shoe with side clips was placed post operatively. An additional 'bridging' plate fixed to the dorsal hoof wall with PMMA across the defect was used in 3 cases treated by CR.

Outcome

The findings are summarised in Table 1. All horses remained comfortable post operatively once hoof stabilisation had been achieved. Thirteen (50%) horses suffered from post operative complications. Complications occurred in 10 (71%) horses treated by CR and in 3 (25%) horses treated by PR. Three (11%) horses had histologically confirmed recurrence of the keratoma, 2 of which had been treated by PR. Repeat debridement of this tissue was performed successfully under standing sedation and local analgesia. Excess granulation tissue formed at the surgical site in 8 (31%) horses, 7 of which had been treated by CR. Debridement of this tissue was performed successfully under standing sedation. Two (8%) horses, both treated by CR, developed a hoof crack originating at the surgical site. The crack was complete in one horse and partial in the second horse. A hoof wall deformity

remained in one horse 12 months post operatively. An infection developed underneath the filler in *Case 6*, 10 weeks post operatively, which caused a severe lameness. The horse presented 3 weeks after the onset of this infection but was 6/10 lame on the contralateral (unoperated) limb at this stage. There was clinical and radiological evidence of severe laminitis, presumably a consequence of mechanical overload. Despite treatment of both the infection and the laminitis, the gelding was subjected to euthanasia due to ongoing deterioration of the laminitic foot.

There was a reduced convalescent time following PR compared with CR. Horses were back in full work in a median of 10 months following CR and in a median of 7 months following PR. Overall, the hoof wall took 6–12 months to grow out, a median of 10 months following CR and 8 months following PR. All surviving horses were sound and returned to their previous exercise level 6–36 months post operatively.

Statistical analysis

Horses undergoing CR were significantly more likely to develop post operative complications than those undergoing PR ($P<0.01$). None of the analysed factors were significant determinants of outcome.

The time to post operative soundness was not significantly different between the 2 techniques. However, the time to post operative attainment of the previous exercise level was significantly less following PR than following CR ($P<0.01$). For horses treated by CR, there was no statistical difference in the time to full work between horses suffering a post operative complication and those not suffering a complication. The same finding was true for horses treated by PR. There was no significant difference in the post operative complication rate or the time to full work post operatively between the 6 cases where the 'window' was extended to the coronary band but which were treated by PR compared with the 6 cases where the 'window' did not extend as far proximally and which were also treated by PR.

Discussion

The surgical technique chosen for each case in this study was not randomised but based upon the clinical findings. Therefore, with regard to the post operative complication rate and time to full work, the surgical technique cannot be separated from the location of the proximal extent of the keratoma. There was no significant difference post operatively in the complication rate or period to full work in cases treated by PR where the keratoma and hoof wall 'window' extended to the coronary band and where it did not; and it is therefore probable that the influence of the surgical technique was greater than the extent of abnormal tissue in affecting outcome.

The aetiology of keratomas is unknown. The current interpretation is that they result from excess horn production by the germinal epithelial cells, initiated by either trauma or a subsolar abscess (Honnas *et al.* 1988, 1994; Chaffin *et al.* 1989). In 7 cases reported by Lloyd *et al.* (1988), 2 had a history of a subsolar abscess and 4 of hoof trauma. In comparison, 22 of our 26 (85%) cases had a history of a subsolar abscess, which was recurrent in 17 cases. No history of hoof trauma was recorded. Keratomas have been diagnosed when there has been no history of a hoof wall insult (Lloyd *et al.* 1988; Chaffin *et al.* 1989; Chan and Munroe 1997), which was the case in 3 (12%) horses in our study.

Lameness localised to one foot is the most common presenting sign and can vary from mild to severe (Lloyd *et al.* 1988; Pickersgill 2000; O'Grady and Horne 2001). A prolonged but intermittent lameness has been associated with the presence of a subsolar abscess. The distal growth of the keratoma disrupts the white line, allowing bacterial invasion and the development of an abscess (Wagner *et al.* 1986; Wyn-Jones 1988; Honnas *et al.* 1994). The lameness associated with the abscess usually subsides when the abscess is drained. Twenty-two (85%) cases in this study had a history of a subsolar abscess. Insidious onset lameness, associated with the keratoma itself, has been attributed to pressure on the sensitive laminae and distal phalanx from the expanding keratoma (Honnas *et al.* 1988; Lloyd *et al.* 1988; Chaffin *et al.* 1989; Honnas 1991). The lameness was insidious in onset in 2 (8%) of the horses in our study. One keratoma in this series (4%) was not the cause of lameness, although abnormal tissue was identified at the white line.

Pressure from the keratoma placed on the overlying epidermis may cause outward deviation of the hoof wall, thinning or discoloration of the overlying epidermis, or thickening and deviation of the white line at the sole (Honnas *et al.* 1988; Chaffin *et al.* 1989; Chan and Munroe 1997; O'Grady and Horne 2001). Deformity of the hoof wall has been reported as a common clinical sign (Lloyd *et al.* 1988; Chaffin *et al.* 1989), but a bulge in the dorsal hoof wall was evident in only 5 (19%) horses and deviation of the white line in one (4%) horse in the present series. It is likely that such deformities were not apparent due to the presence of the subsolar abscess and/or previous veterinary intervention.

Pressure from the expanding keratoma is also thought to cause focal resorption of the underlying bone, resulting in the characteristic clearly defined, smoothly marginated semicircular radiolucent defect in the solar margin of the distal phalanx. This finding was present in 25 (96%) cases, with marginal sclerosis being present in 6 (23%) cases in our study (Wagner *et al.* 1986; Chaffin *et al.* 1989; Chan and Munroe 1997; Butler *et al.* 2000). Keratomas do not always produce the characteristic radiolucent defect (Lloyd *et al.* 1988; Honnas 1991), either because the keratoma has not enlarged sufficiently to cause bone resorption, or because the keratoma does not extended a sufficient distance distally (Chan and Munroe 1997). New bone formation on the dorsal surface of the distal phalanx has been observed and was seen here in 2 cases (Chan and Munroe 1997).

Treatment involves complete removal of the abnormal tissue from the hoof wall and corium (Honnas 1991; Honnas *et al.* 1994). The present report is unique in the specific comparison made between CR and PR for keratoma removal. In this study, horses undergoing CR were significantly more likely to suffer from post operative complications.

Recurrent growth of keratomas is considered to be one of the more serious surgical complications and a primary reason for persistent lameness following surgical removal (Hickman 1964; Lloyd *et al.* 1988). Recurrence is thought to occur if surgical excision and local tissue debridement is not sufficiently aggressive (Lloyd *et al.* 1988). Keratomas commonly originate at the coronary band with subsequent extension distally (Honnas 1991). Previously, CR was thought necessary to achieve complete excision of the keratoma (Honnas *et al.* 1988, 1994; Lloyd *et al.* 1988; Chaffin *et al.* 1989; Seahorn *et al.* 1992); however, PR has proved to be successful in this and other studies (Wagner *et al.* 1986; Lloyd *et al.* 1988; Honnas 1991), as long as complete removal of the abnormal tissue is achieved. At the time of surgery, 'complete removal' of the keratoma can be based only on visual assessment of the surgical site

following the removal of any abnormal tissue. Histopathology can later verify the 'completeness' of the removal by examining the margins of the abnormal tissue, provided that significant tissue destruction has not occurred, which was not always the case in our study. Keratoma removal was more difficult when PR was performed, due to the smaller hole in the hoof wall and decreased visualisation of the surgical site. In our series, recurrence of the keratoma occurred in 3 horses, 2 of which had been treated by PR. However, statistical analysis of this particular complication in relation to the surgical technique performed could not be carried out due to the small number involved.

Hoof wall instability caused by the surgically created hoof defect was reported to be a limiting factor for return to use (Helms *et al.* 1994). PR preserves the hoof wall and thus its intrinsic stability to a much greater degree than does CR (Honnas 1997; Frisbie and Trotter 1998). Hoof wall instability can result in post operative lameness (Lloyd *et al.* 1988; Chaffin *et al.* 1989; Honnas 1991). In 5 cases treated by CR, the post operative lameness at the walk was greater than 2/10 and improved immediately following hoof wall stabilisation with a heart-bar shoe and bolted-on hospital plate. In addition, 3 of these cases had a 'bridging' metal plate applied to the dorsal aspect of the hoof wall across the defect, fixed in place using PMMA. This method was used as, in the authors' experience, it has been more successful than screwing small plates across the defect, fixing plastic tabs across the defect or using fibreglass patches (Curtis 1999). None of the horses treated by PR demonstrated a lameness of greater than 2/10 post operatively, suggesting improved stability due to the remaining distal bridge of hoof wall. Movement due to hoof wall instability, as well as surface infection, predispose to formation of excessive granulation tissue at the surgical site (Chaffin *et al.* 1989; Honnas 1991; Stashak 1991). Topical antibiotics were used in all cases to decrease the risk of surface infection. Seven of the 8 horses that developed excess granulation tissue were treated with CR. Although the excessive tissue was trimmed and the hoof wall stabilised, the convalescence period was prolonged compared with that after PR. Hoof wall instability can also predispose to hoof crack formation, which occurred in 2 (8%) horses in this series, both of which were treated with CR (Goodness and White 1998). Damage to the coronary corium at the time of resection may result in production of weak horn, increasing the propensity for formation of a hoof crack (Chan and Munroe 1997). The convalescent period was greatly increased in both these horses. This study demonstrates the complications associated with hoof wall instability and the need for adequate stabilistion mechanisms following CR (Honnas 1997; Frisbie and Trotter 1998). The degree of stabilisation that is needed depends upon the amount of hoof wall instability.

Reconstruction of the hoof wall protects the underlying laminae, stabilises the hoof wall and allows horses to return to work more quickly (Honnas 1997; Frisbie and Trotter 1998). Polymethylmethacrylate was used successfully in all horses in our series to fill the hoof wall defect, except in *Case 6*. In this horse, infection developed underneath the filler as a result of either trapped bacteria or thermal damage and tissue necrosis caused by the curing process of the PMMA (Helms *et al.* 1994; Curtis 1999). The standard protocol of hoof wall preparation was performed in all cases prior to filling of the defect. This included assessment of the thickness of keratinised tissue, removal of loose horn and debridement of the defect.

Honnas (1997) reported a reduced convalescent time following PR compared with CR, although no data were reported to support this statement. In the study reported here, horses were significantly more likely to return to full work more quickly following PR than following CR. There was also no significant difference in the time to full work between horses suffering a post operative complication and those not suffering a complication within each surgical group. This finding suggests that the surgical technique and not the presence of a complication influences the time to full work. The proximity of the keratoma to the coronary band did not affect the time to return to full work in the cases treated with PR. Again, this finding demonstrates that the surgical technique, as opposed to the proximal extent of the abnormal tissue, accounts for the difference in the post operative complication rate and convalescence time between the 2 techniques. The time required for regrowth of the hoof wall was variable. Although not significantly different, the median time taken was shorter following PR (8 months) than following CR (10 months). This may be related to the size of the 'window' made in the hoof wall of horses undergoing PR, which was not recorded, and the proximal limit of the resection. The location of the defect around the hoof wall may also be a determinant, since the hoof wall is longer at the toe than at the quarters.

The prognosis for a return to soundness after complete surgical excision of a keratoma, uncomplicated resolution of any infection present and regrowth of the defect in the hoof wall is favourable to excellent (Wagner *et al.* 1986; Lloyd *et al.* 1988; Reeves *et al.* 1989). This was confirmed in our series, in which all horses except one returned to soundness and to their previous level of performance.

In conclusion, PR is the preferred technique for keratoma removal because hoof wall stability is maintained, the complication rate is decreased and the convalescent time is shortened. When performing PR, preservation of as much of the hoof wall as possible is recommended; however, adequate resection is necessary to ensure removal of the entire keratoma in order to decrease the risk of recurrence.

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Manufacturers' addresses

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[2]C-Vet Veterinary Products, Leyland, Lancashire, UK.
[3]Intervet UK Ltd, Milton Keynes, Buckinghamshire, UK.
[4]Arnolds Veterinary Products Ltd, Shrewsbury, Shropshire, UK.
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[6]Aldrich, Gillingham, Dorset, UK.
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