FORGE KNOWLEDGE

Steven Butler *DipWCF*

Steven Butler completed his apprenticeship with Robin May AWCF in his home town of Wokingham, Berkshire. Studying psychology, human biology and history to A level helped him through the theoretical knowledge of farriery and gave him a degree of curiosity and cynicism and a questioning disposition. He completed his farriery diploma at Warwickshire in 2007. His shoeing work is on a mix of dressage and eventing horses along with happy hackers. The most satisfying part of his work involves remedial and corrective work with local vets. He says there is nothing more satisfying than taking a lame horse and helping in its recovery. He has a four-year-old daughter Isla and lives with his partner, Carly, on a cattle farm in Hampshire.

Rhiannon Morgan *BSc, BVSc, CertAVP, PhD, MRCVS*

Rhiannon Morgan is the Senior Clinical Training Scholar in large animal diagnostic imaging at the Royal Veterinary College, London. She graduated from the University of Liverpool in 2009 and went on to complete an equine internship at the Animal Health Trust, Newmarket. After time spent in ambulatory equine practice, she returned to Liverpool to undertake a PhD investigating the driving factors of osteoarthritis in the horse, specifically looking at mechanisms to reduce inflammatory mediators. She has also completed a postgraduate certificate in advanced veterinary practice and produces an equine veterinary podcast. Her main areas of interest include imaging of the head, ultrasonography of the back and the progressive area of joint imaging.

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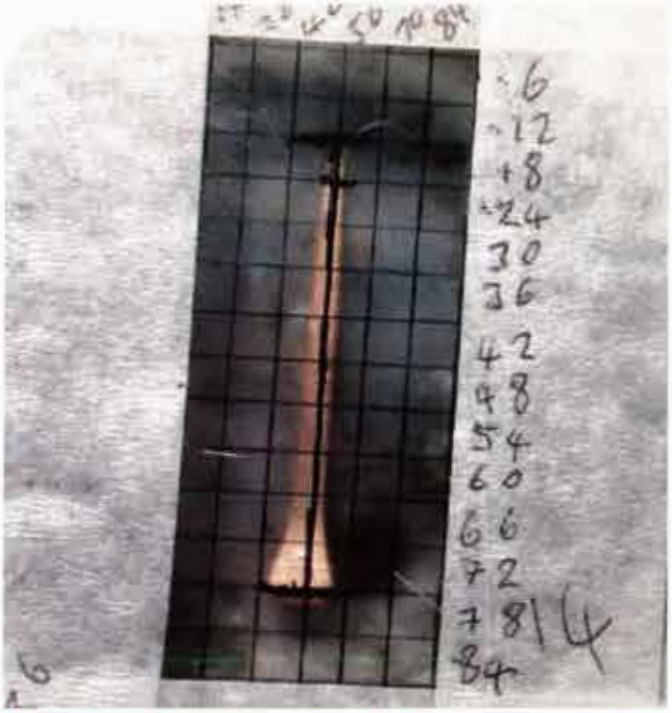

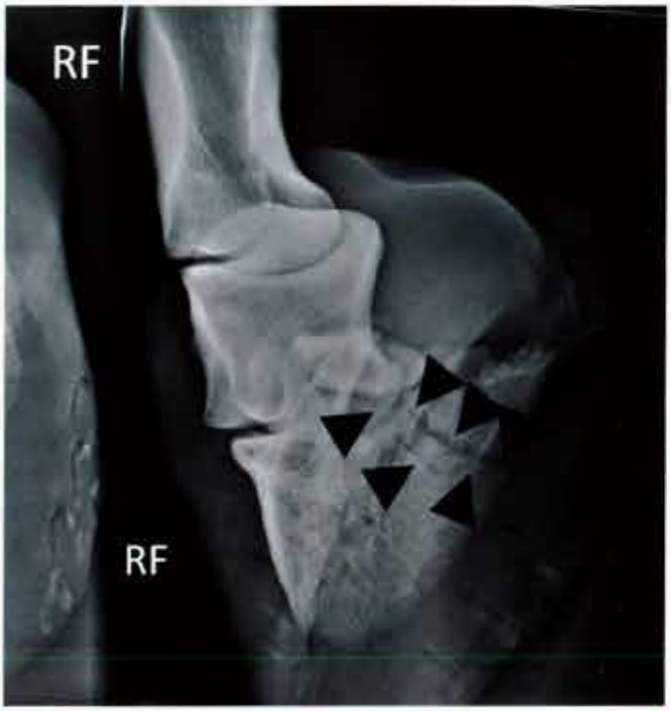

Technical article

Self-assessment

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By Steven Butler DipWCF

Nailing the case for copper?

Frequently asked by clients about the value of copper nails, Steven Butler set out to investigate whether they were a fad or a genuinely useful item for improving hoof health.

COPPER-COATED nails are increasingly being used by farriers on the understanding that the copper coating acts as an antimicrobial agent, reducing the risk of bacteria and fungi entering the foot along the nail tract. Having been asked regularly by clients about the value of copper nails, I set up this study with the objective of finding out whether copper nails do have antimicrobial properties that could help improve the health of the equine hoof.

Study setup

I prepared 45 agar plates, adding a bacterial yeast feed to help any bacteria grow. The number of test plates was chosen to give a large enough set of final data to be able to gather evidence – too small a sample could lead to false positives or data that are too constricted to draw any conclusions.

Hoof trimmings from freshly trimmed hooves were collected, put in to a paper cup and a small amount of water was added to prevent everything drying out and to help form a bacterial culture. Like humans, most bacteria need a source of water to grow: 'Bacteria have these same needs [food, water, shelter]: they need nutrients for energy, water to stay hydrated, and a place to grow that meets their environmental preferences. The ideal conditions vary among types of bacterium, but they all include components in these three categories' (Taylor 2018).

After three days, the hoof trimmings started to smell particularly foul, the stench being an indicator of bacterial growth, caused when the bacteria start to break down the tissues of the hoof horn and excrete various bad smelling chemicals. Another observation was the liquid within the cup had turned black. It was this bacterial soup that was spread onto the plates and used to coat some of the nails.

Table 1 details the treatments applied to each of five groups of nine plates.

The nailing process was simulated for the nails applied to plates in groups C and D; this involved pushing the nails through the nail holes on pieces of the hoof trimmings with the aim of seeing how many bacterial cells were retained on the nail shanks and then transferred over to the agar plates.

All the complete agar plates and their respective nails were then placed into a room temperature dark cupboard for six weeks. This simulated the average time of a shoeing cycle and how long the nails would be retained in a particular nail hole.

To gather bacterial growth data and corrosion data from the nails a grid method was used. This involved a transparent sheet of plastic broken down into 5x5 mm squares (Fig 1); any bacterial growth within a given square was scored as a 1. Only data from 1 cm around each nail were needed as the study's aims were to find out the nails' direct effects on bacteria rather than if bacteria grew away from the nails. Using the grid method, there was a potential maximum of 84 squares for the bacteria to grow in so, for example, if 42 squares of the possible 84 contained bacteria, this would give a 50 per cent yield.

TABLE 1: Treatments applied to five groups of nine agar plates

Plate group	Agar	Nail
A	Inoculated with bacterial culture	Copper, dipped in bacterial culture and laid on agar plate
B	Inoculated with bacterial culture	Steel, dipped in bacterial culture and laid on agar plate
C	Left sterile	Steel, pushed through hoof pieces and laid on agar plate*
D	Left sterile	Copper, pushed through hoof pieces and laid on agar plate*
E	Inoculated with bacterial culture	Copper, scuffed up and laid on agar plate

* Nails were pushed through pieces of hoof to replicate the nailing process

The nail itself was also bisected by a line to give 10 squares on either side, resulting in 20 squares in total (Fig 1). Any corrosion on the nail was scored as a 1; therefore, two areas of corrosion would result in a 10 per cent data value.

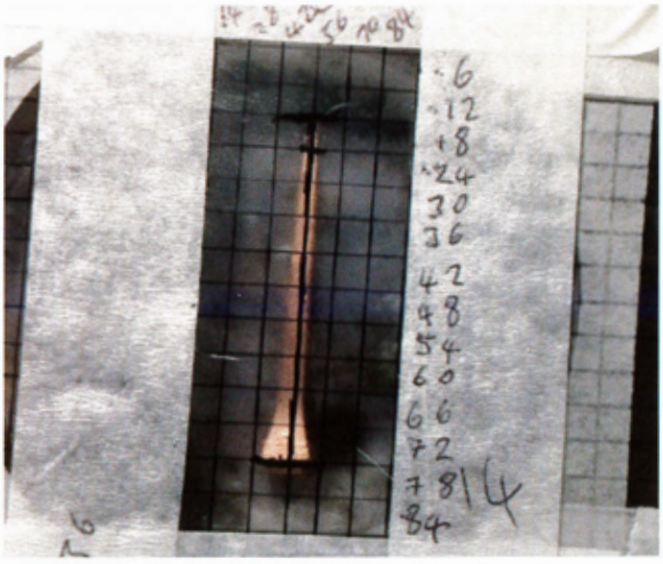

Fig 1. The grid method used to score bacterial growth and corrosion

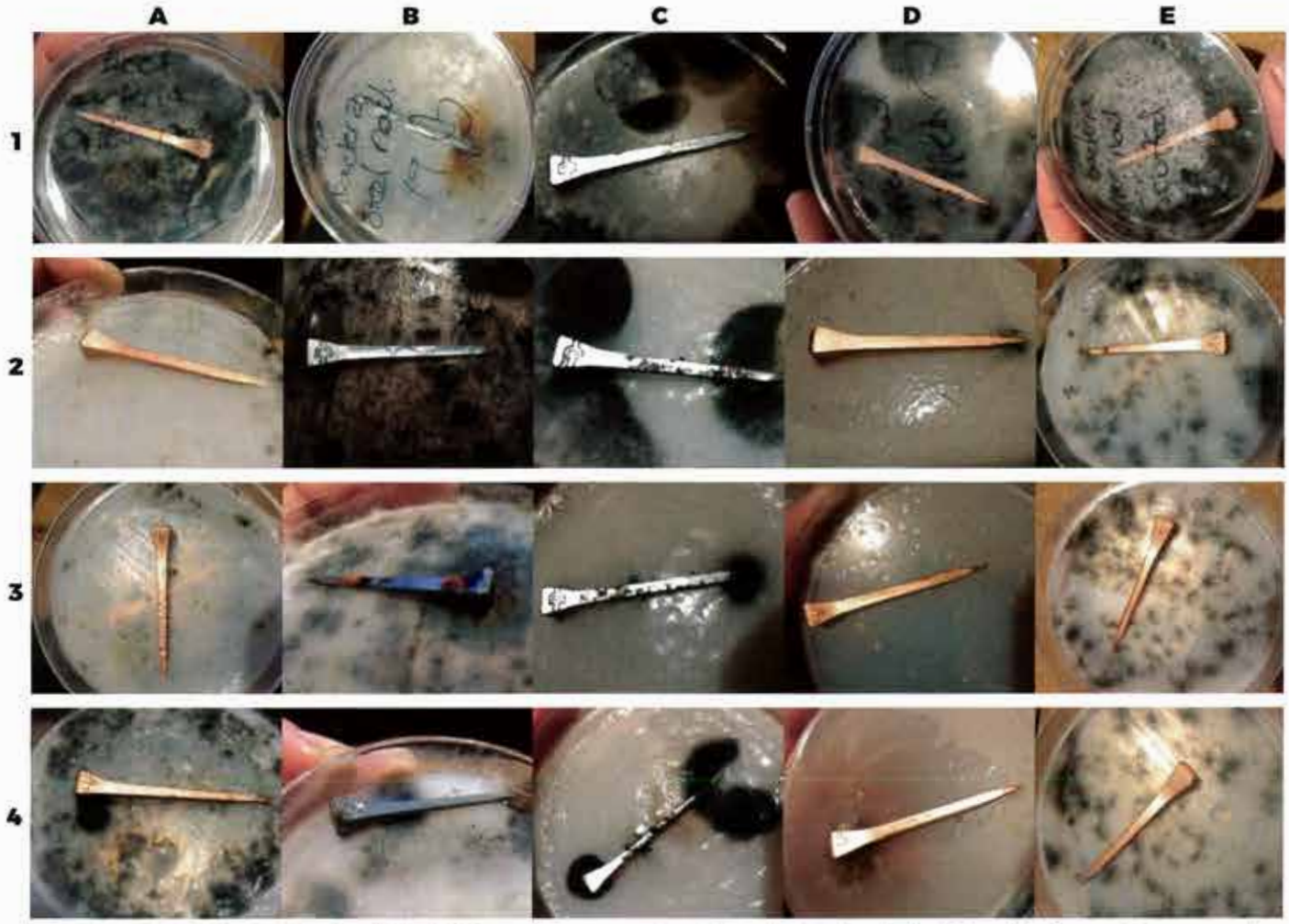

Fig 2. The agar plates after six weeks of incubation in darkness at room temperature. Column A: plates inoculated with bacterial culture medium, copper nails dipped in culture medium and laid on the plates. Column B: plates inoculated with bacterial culture, steel nails dipped in culture medium and laid on the plates. Column C: plates left sterile, steel nails pushed through pieces of hoof trimming and laid on the plates; Column D: plates left sterile, copper nails pushed through pieces of hoof trimming and laid on the plates. Column E: plates inoculated with bacterial culture medium, copper nails scuffed up and laid on the plates

Results

Fig 2 shows the groups of plates after the six weeks of incubation. It is important when comparing the images in Fig 2 to only compare them with their counterparts within the same experiment style: therefore, the plates in groups A, B and E should be compared together, as should those in groups C and D.

Table 2 details the bacterial growth scores on plates in groups A, B and E (that is, the plates that were inoculated with bacterial culture). It can be seen from both Fig 2 and the data in Table 2 that the bacteria did not die off around either the copper or the steel nails. Out of the 27 plates within this data set, only seven (26 per cent) plates showed bacterial growth in fewer than 50 per cent of the grid squares (plates A2, A8, B1, B7, B8, E2 and E6).

Bacteria grew up to and around the copper nails just as effectively as it did up to and around a steel nail as can be seen by comparing plates A5, B5 and E5 in Fig 2.

Table 3 shows the bacterial growth scores on the nails that were pushed through the hoof trimmings to simulate the nailing process. The data show two distinct anomalies: unlike the other steel nails, which had bacterial growth scores ranging between 43 and 84, the nail on plate C3 had a bacterial growth score of only 11. Among the copper nails, for which the bacterial growth scores generally ranged from 3 to 31, the nail on plate D1 showed the maximum growth score of 84. It was later found that some of the agar plates that should have been left sterile had been accidentally contaminated with bacterial culture. However, because bacteria cannot 'jump'

TABLE 2: Scores for bacterial growth (maximum score is 84) on plates in groups A, B and E following six weeks of incubation. Plates showing at least a 50 per cent reduction in bacterial growth are highlighted in red

	Plate group		
Plate number	A	B	E
1	84	30	84
2	20	84	48
3	66	80	73
4	79	78	63
5	79	79	77
6	60	84	11
7	57	6	75
8	11	10	80
9	84	-	82

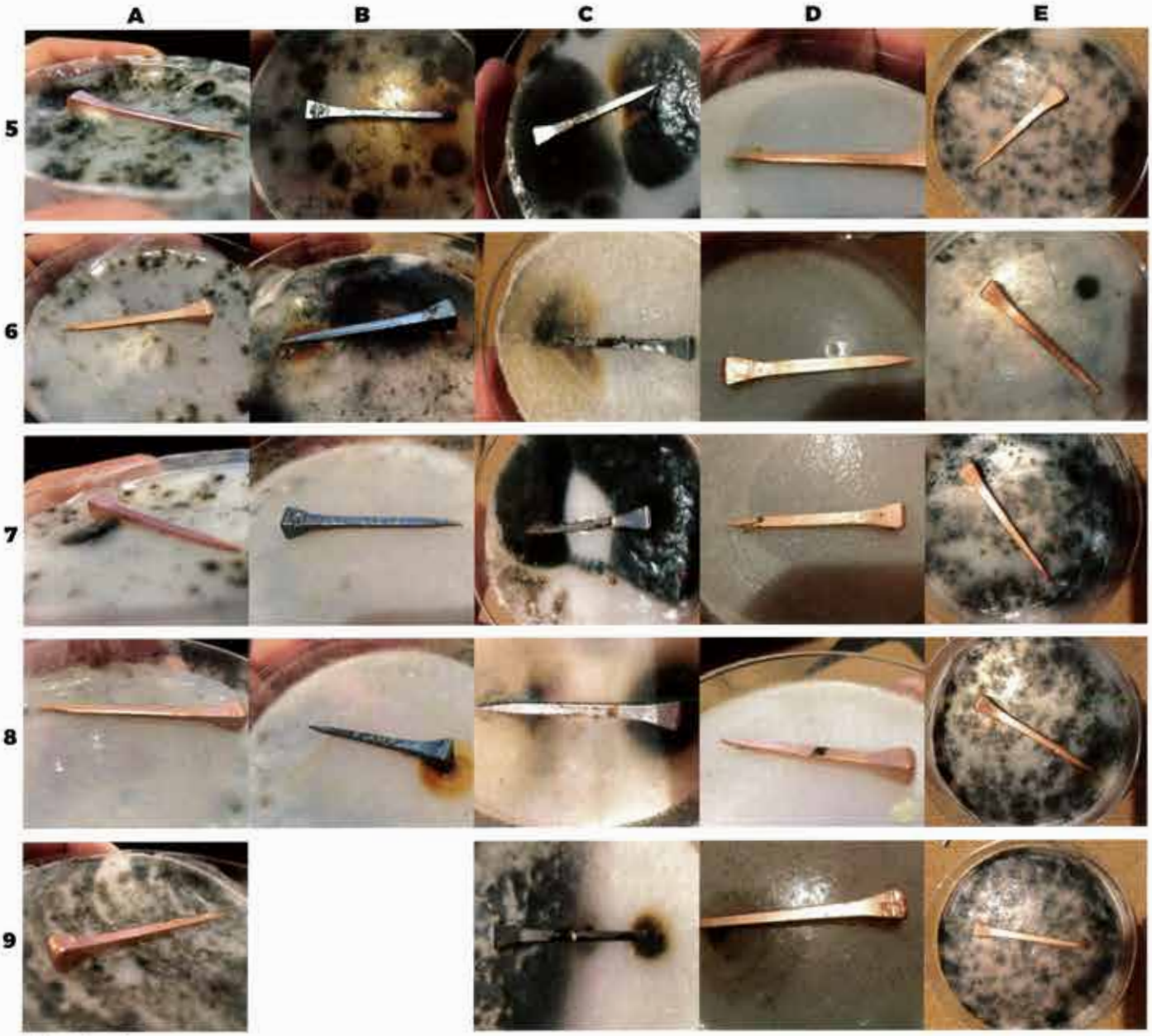

Fig 1 continued

TABLE 3: Scores for bacterial growth on plates in groups C and D following six weeks of incubation

Plate number	Plate group	
	C	D
1	59	84
2	58	3
3	11	7
4	43	31
5	79	6
6	46	5
7	76	5
8	84	11
9	64	26

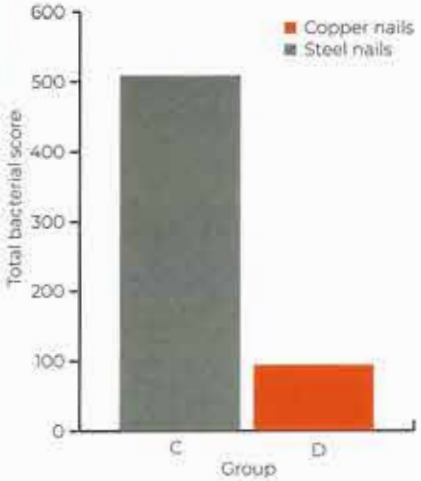

Fig 3. Total bacterial growth scores for steel (group C) and copper (group D) nails following simulated nailing

from one part of an agar plate to another without leaving evidence, it was felt that, by collecting data from only the immediate area around the nail, the impact of this error would be minimised.

Removing the two anomalous results allows a much more realistic interpretation of how bacteria and nails relate to each other within the equine hoof. Fig 3 shows that the occurrence of bacterial growths along steel nails after simulated nailing is high (509 bacterial episodes out of a possible 672). In contrast, bacterial growths along copper nails after the same simulated nailing were considerably less (94 bacterial episodes out of a possible 672).

It therefore appears that bacterial transfer and colony growth is approximately five times more likely with steel nails than with copper nails. Overall, it was found that the chance of a bacterial occurrence happening with a steel nail was 75.74 per cent, whereas the chance of a bacterial

TABLE 4: Scores for corrosion recorded on copper and steel nails in each group of plates (scored out of a possible maximum of 20)

Plate number	Plate group				
	A	B	C	D	E
1	0	6	12	0	2
2	0	4	16	0	2
3	0	10	19	0	2
4	2	6	14	0	0
5	0	8	8	0	0
6	0	4	16	0	2
7	0	6	16	0	2
8	0	8	8	0	2
9	2	-	14	2	2

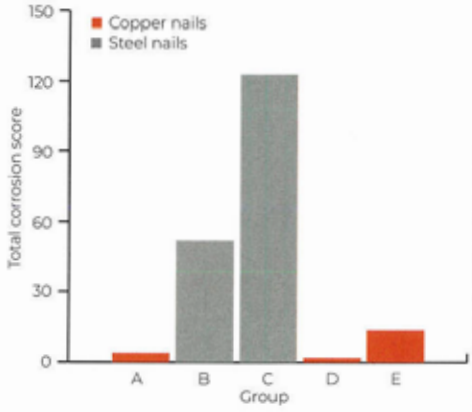

Fig 4. Total corrosion scores for the nails in each group: each nail could receive a maximum score of 20, and there were nine nails assessed in each group, therefore the maximum total score for each group was 180

occurrence happening with a copper nail was just 13.99 per cent.

Table 4 and Fig 4 record the rust and corrosion scores for the copper and steel nails in each group. It can be seen that there is a difference between the copper and steel nails in their resistance to corrosion – all the steel nails corroded to some degree compared to 7.78 per cent of copper nails.

It should be noted that all the corrosion found on the copper nails was at the very tip of each nail; no copper nail contained any rust or corrosion along its shank. To put this into a shoeing context, all rust that does occur on a copper nail would be on the exterior of the hoof wall. In contrast, rust and corrosion appeared all over the steel nails; hence, this would be found both internally and externally of the hoof wall.

Conclusion

The findings of this study confirm that, at least in an in vitro environment, copper nails appear to inhibit the growth of bacteria following a simulated nailing process, the bacteria seemingly being unable to adhere to the copper or being killed by it.

The data show a five times higher chance of bacterial growth within each nail hole when a steel nail is used compared to a copper nail. Therefore, it could be suggested that, when nailing through the hoof wall (which will be naturally colonised with bacteria) a copper nail would help maintain a healthier hoof compared to a steel nail.

There may be another aspect of copper nails that contributes to a healthier hoof. Copper nails do not corrode like steel nails. The agar plates showed that there was an increased bacterial presence within the areas of nail that had corroded. Corrosion increases the surface area on which bacterial colonies can grow, potentially offering them a greater chance to develop and infect the surrounding horn. Also, Curtis (2006) notes that the process of oxidation breaks down the sulphur bond within the intertubular, intratubular and tubular horn. As copper does not rust it can be surmised that the breakdown of wall structures will not happen so quickly, to the extent that they will be trimmed out before any real damage can occur.

This study demonstrates that copper nails do have some antimicrobial potential, and that they could help to improve the state of the hoof wall given that they have reduced amounts of bacteria growing on them compared with steel nails. It is doubtful, however, that they would help to reduce areas of systemic bacterial ingress, such as seedy toe, in their own right. That said, when used in conjunction with other antibacterial efforts, nailing through a contaminated area using copper nails could reduce the risk of transferring the bacteria up the nail hole to uninfected areas by fivefold in comparison with a steel nail. There is also the possibility that copper nails would reduce the risk of an infection occurring due to a nail prick or nail bind due to the decreased likelihood of them carrying bacteria. However, it would be unethical (and almost impossible) to test this possibility.

The limitations on the nails are that they do not kill off well-established bacteria to any great degree. It must also be noted that copper nails are not 100 per cent copper; instead, they are steel nails with a copper-plated surface applied.

Within the farriery industry there are many questions relating to the use of copper nails: 'Are copper nails just a fad?', 'Do they actually work?', 'Are they worth the extra cost?' This study prompts a further question: what do these findings mean for copper-plated shoes?

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Self-assessment: why is this horse lame?

By Rhiannon Morgan BVSc, CertAVP, PhD, MRCVS

Rhiannon Morgan, senior clinical training scholar in large animal diagnostic imaging at the Royal Veterinary College, describes a horse referred for investigation of acute lameness and asks you to consider what might be causing the problems.

Case description

An 11-year-old Warmblood mare, with no history of lameness and used for medium level show-jumping, was admitted to the Royal Veterinary College's referral hospital for further investigation of lameness. One month before referral, she had tried to jump a fence in her field, and subsequently became acutely lame on the right fore. There was no response to four days of box rest and non-steroidal anti-inflammatory drugs. Radiographs were acquired at the time, but failed to demonstrate any pathology.

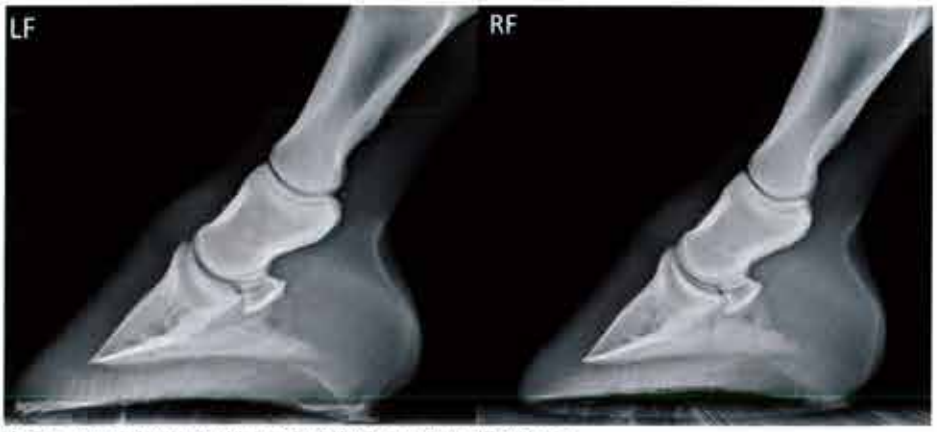

Fig 1. Lateromedial projections of the left (LF) and right (RF) forefeet

Clinical examination at the referral hospital

Clinical examination revealed exaggerated digital pulses and increased heat in her right forefoot. At walk she landed toe first with her right forefoot and had reduced extension of her right metacarpophalangeal (fetlock) joint. At trot in a straight line on a hard surface, she was grade 5/10 right forelimb (RF) lame. When lunged on a soft surface, she was grade 4/10 RF lame on the left rein, and 5/10 RF lame on the right rein. The mare was not lunged on a hard surface. When pressure, using hoof testers, was applied, a mild response was elicited over the medial aspect of the RF sole.

Diagnostic imaging

Due to the clinical signs, lameness examination and response to hoof testers, the front feet were radiographed. A complete series of foot radiographs including a weight-bearing lateromedial and a weight-bearing dorsopalmar projection were acquired. Lateromedial radiographs of both front feet are shown in Fig 1. The marker is always placed on the dorsal aspect in lateromedial radiographs. Are there any changes detectable on these radiographs?

Using a Hickman block to angle the foot, two dorso60°proximal-palmarodistal oblique projections were also taken, one focusing on the distal phalanx, also known as the upright pedal view (Fig 2) and a further collimated radiograph to look at the navicular bone. In these views, the marker is placed on the lateral aspect of the limb. Can you see any pathology that would match the irregularity seen in Fig 1?

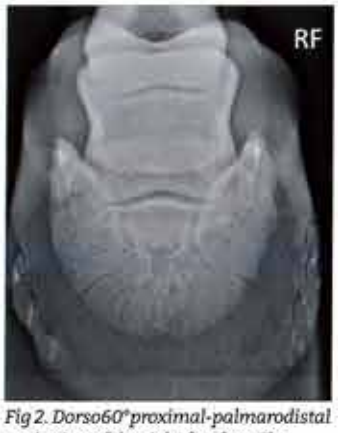

Fig 2. Dorso60°proximal-palmarodistal projection of the right forefoot. The marker is placed on the lateral aspect of the limb. This view is non-weight-bearing, resting in a Hickman block, and highlights the distal phalanx

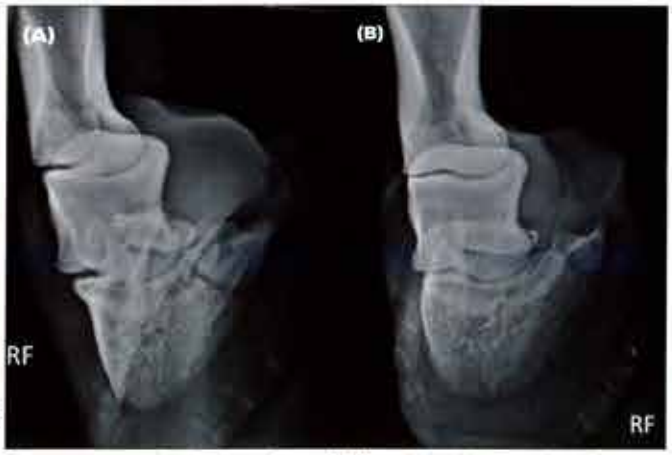

Fig 3. Dorso45°medial-palmarolateral oblique (A) and dorso45°lateral-palmaromedial oblique (B) projections of the right forefoot. This view is non-weight-bearing, resting in a Hickman block, and highlights the wings of the distal phalanx

Oblique radiographic projections were also acquired to look at the wings of the distal phalanx. Using a horizontal x-ray beam and the foot angled in the Hickman block, the x-ray beam was moved 45 degrees from dorsal to the medial or lateral side, to highlight the medial or lateral wings of the distal phalanx, respectively. Fig 3 shows both medial and lateral oblique radiographs. The dorso45°medial-palmarolateral oblique radiograph clearly highlights the problem.

What is your diagnosis? The answer is given on p 52.

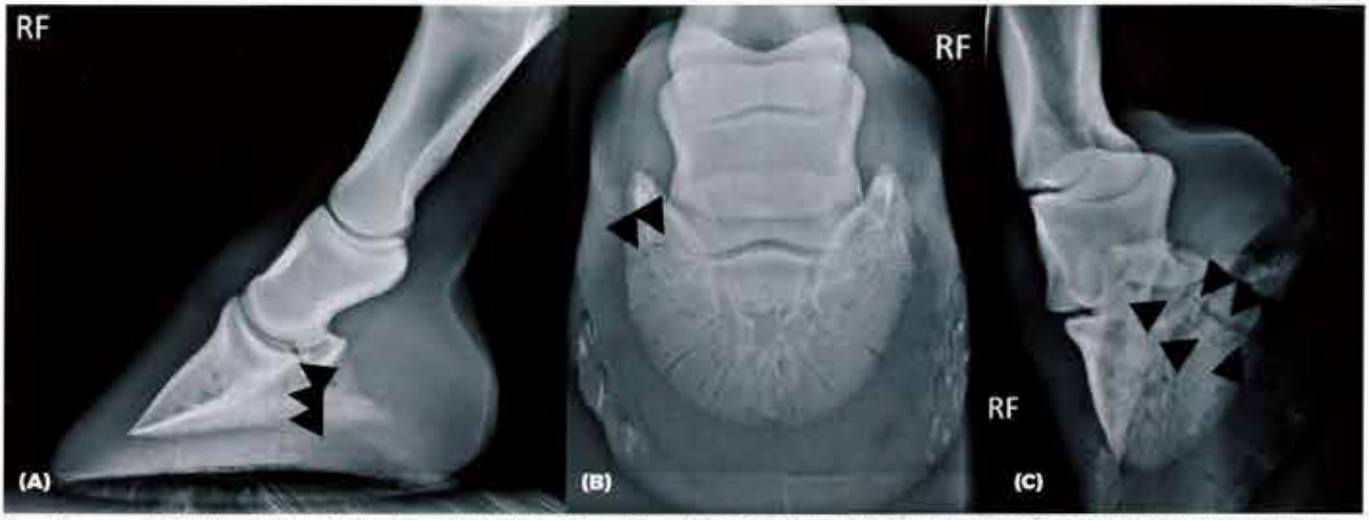

Fig 4. Lateromedial (A), dorso60°proximal-palmarodistal oblique (B) and dorso45°medial-palmarolateral oblique (C) radiographs of the right forefoot. The black arrows highlight two irregular radiolucent lines coursing across the medial wing of the distal phalanx and entering the distal interphalangeal joint, as seen in (C). This is consistent with a complete intra-articular fracture of the medial wing of the distal phalanx, also known as a type 2 distal phalanx fracture

Findings

A radiolucent line extends across the medial wing of the distal phalanx, from the palmar aspect of the articular surface of the distal phalanx (within the distal interphalangeal [coffin] joint) distally to the solar margin, and from the medial to lateral aspects of the wing (Fig 4). Where the fracture line extends across the articular surface, there is a small step and very mild palmar displacement of the palmar bone fragment. These findings are consistent with a type 2 fracture (articular) of the RF distal phalanx with very mild displacement of the palmar fragment and mild remodelling of the fracture margins.

Distal phalangeal fractures are classified according to their location within the distal phalanx and whether or not they extend into the articular surface (Honnas and others 1988). Type 2 fractures are parasagittal and extend from the distal interphalangeal joint to the medial or lateral aspect of the solar margin. Two radiolucent lines were highlighted in the dorso45°medial-palmarolateral oblique radiograph (Fig 4C) which further supports this; the two lines are consistent with entry and exit points of the fracture through the medial and lateral borders of the wing, making this a complete fracture.

A small step in the articular surface of the distal phalanx at the fracture site was identified, which suggests the articular cartilage is damaged. This may predispose the joint to future secondary osteoarthritis, and may subsequently affect the horse's athletic ability.

The prognosis for return to original or expected level of use in horses with an articular type 2 fracture is 69.6 per cent, lower than for similar non-articular fractures (Rijkenhuizen and others 2012). These fractures can be treated conservatively using just box rest, but ideally with a foot cast and box rest. Others have employed surgical fixation using a lag screw technique (Honnas and others 1992). During the healing process, a fibrous union first develops, which will appear as a radiolucent line on radiographs. This should ossify within six to 12 months; however, some will never have complete bony union radiographically, even though they are sound (Butler and others 2017).

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