Farriery for Hoof Wall Defects
Quarter Cracks and Toe Cracks

R. Scott Pleasant, DVM, MS\textsuperscript{a}, *,
Stephen E. O’Grady, DVM, MRCVS, APF\textsuperscript{b}, Ian McKinlay\textsuperscript{c}

INTRODUCTION

The equine hoof capsule serves to support and protect the internal structures of the foot. Conditions that result in the loss of the structural integrity of the hoof capsule, such as full-thickness quarter cracks and toe cracks (full-thickness hoof wall fractures), are not uncommon and may result in lameness. Once the hoof wall has been fractured, the healing process is primarily replacement by growth. New growth originates from the coronet; depending on the region of the crack, it may take 4 to 12 months for the damaged hoof wall to be replaced. In most cases, healing by replacement occurs uneventfully if the underlying causes of the crack are addressed and the horse is allowed appropriate rest. The management of the underlying causes is paramount in reducing the likelihood of recurrence of performance-limiting cracks.

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\textsuperscript{a} Department of Large Animal Clinical Sciences, Virginia-Maryland Regional College of Veterinary Medicine, Virginia Tech, Phase 2, Duck Pond Drive (0442), Blacksburg, VA 24061, USA; \textsuperscript{b} Northern Virginia Equine, PO Box 746 Marshall, VA 20116, USA; \textsuperscript{c} PO Box 66, South Amboy, NJ 08879, USA

* Corresponding author.

E-mail address: rpleasan@vt.edu

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Frequently, veterinarians and farriers encounter situations when it is important for horses with full-thickness quarter cracks or toe cracks to remain in work. These situations require the use of techniques that not only address the underlying causes but also stabilize the injured tissues. The purpose of this article is to discuss the predisposing factors for full-thickness quarter and toe cracks and to provide strategies for managing these hoof wall defects.

RELEVANT ANATOMY AND BIOMECHANICS

The equine hoof capsule comprises the hoof wall, sole, frog, and bulbs of the heel. The hoof capsule is made predominately of keratinized epidermal cells and forms a tough, obliquely oriented, truncated, incomplete cone that is folded in on itself on each side at the heels (Fig. 1A). The hoof wall is typically thickest in the toe region and becomes thinner and more elastic toward the heels. The medial hoof wall is usually straighter (less angled) and more upright (steeper) than the lateral hoof wall.¹

The hoof wall comprises 3 morphologically distinct layers: the stratum externum (periople), stratum medium, and stratum internum (stratum lamellatum) (see Fig. 1B). The stratum medium makes up the bulk of the hoof wall and comprises the tubular and intertubular horn. The tubule density in the stratum medium is highest in the outermost region and declines toward the stratum internum.² This tubule density gradient reflects differences in the mechanical properties across the stratum medium and is

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Fig. 1. The hoof wall: (A) shape, (B) layers, and (C) normal movement during loading.
proposed as a mechanism for modulating the transfer of energy from the rigid outer wall (high tubule density) through the more elastic inner wall (low tubule density) to the epidermal/dermal lamellae interface (and ultimately the distal phalanx). Also, the tubular-intertubular horn interfaces and the tubule zonation within the stratum medium have been suggested to be crack-stopping/diverting mechanisms, causing externally originating cracks to deviate along more tortuous routes and redirecting cracks away from the dermis.3–5

The mechanical behavior of the hoof capsule depends primarily on the physical properties of the materials that make it up (affected by nutrition and hydration) and on its shape (affected by load, limb conformation, and foot care).6 During the stance phase of the stride, the hoof deforms under the weight of the horse and the dynamic loads of locomotion. The oblique, truncated, incomplete cone shape and the decrease in the wall thickness from the toe to heels in the well-shaped hoof causes the toe of the wall to bow backwards and the quarters and heels to flare at the ground surface (spread horizontally) during loading (see Fig. 1C). This pattern of deformation seems to be an extremely efficient mechanism for dampening and distributing the loads of weight bearing and locomotion. Changes in hoof capsule shape away from this ideal may negatively affect its mechanical behavior and predispose it to injury.7

PATHOPHYSIOLOGY OF QUARTER CRACKS AND TOE CRACKS

Many causes for full-thickness quarter cracks and toe cracks have been described, including coronet injuries, inappropriate farrier practices, poor-quality hoof walls (as a result of genetics, nutrition, or environment), white line disease, and hoof capsule distortion. In the authors’ experience, the most common underlying cause of full-thickness quarter cracks and toe cracks is hoof capsule distortion. Accordingly, this discussion focuses on full-thickness quarter cracks and toe cracks caused by hoof capsule distortion.

It is well accepted that the hoof capsule adapts and changes shape according to how it is loaded. Hoof wall growth tends to be slower where most of the weight is borne and faster where the least amount of weight is borne.8 Faulty limb conformation adversely effects how the hoof is loaded, and habitual disproportionate loading will change the shape of the hoof capsule over time. The resulting distortion of the hoof may negatively affect its mechanical behavior, resulting in abnormal stress and strain within its tissues. If the changes in stress and strain become excessive, the hoof wall will be predisposed to injuries, such as full-thickness quarter cracks and toe cracks. Stress and strain to the hoof wall may become excessive in a variety of clinical situations. Stress and strain may become excessive in horses with minor hoof capsule distortion but who experience high loads on their hooves (eg, heavy use or work on hard ground) or in horses with marked hoof capsule distortion but who experience normal loads on their hooves. In either situation, the underlying concept is that there is an imbalance between the load applied and the hoof wall’s capacity to withstand that load. If the hoof wall stress/strain is excessive or repetitive, a full-thickness hoof wall crack may result.

It is important for veterinarians and farriers to recognize the cause and effect of hoof capsule distortion. This hoof capsule distortion may be multifactorial but the most common causes are poor limb/foot conformation and inappropriate farriery. Limb conformation directly affects hoof capsule loading, which affects hoof wall shape. For example, in horses with base-wide conformation (Fig. 2A), the medial heel quarter bears the most weight, which may cause the wall in this area to grow slower and become more vertical. If not managed properly, the medial heel quarter may
eventually become displaced axial to the coronet (roll under) and the coronet at the heel may displace proximally assuming a sheared-heel conformation (Fig. 3A). As a result of the disproportionate load, the lateral heel quarter seems to grow faster than the medial heel quarter, causing a distortion. The resulting hoof distortion negatively affects the mechanical behavior of the hoof wall, causing the medial heel quarter to bend axially at the ground surface and bow outward at the coronet during loading, predisposing to a full-thickness wall crack in the medial quarter region that originates at the coronet and extends distally some distance (a quarter crack) (Fig. 4). On close examination, quarter cracks usually open at the coronet when the foot is loaded and closes when the foot is unloaded. The resulting full-thickness wall crack usually results in performance-limiting lameness.

In horses with base-narrow conformation (see Fig. 2B), the opposite occurs. The lateral heel quarter bears the most weight, tends to grow slower, and becomes more

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**Fig. 2.** (A) Base-wide conformation and (B) base-narrow conformation.

**Fig. 3.** (A) Hoof wall distortion associated with base wide conformation. (B) Hoof wall distortion associated with base narrow conformation.
vertical. The lateral heel quarter may eventually roll under, and the coronet on the lateral side may displace proximally (see Fig. 3B). The resulting hoof wall distortion may result in abnormal bending of the lateral hoof wall that predisposes to lateral quarter crack formation.

Full-thickness toe cracks may occur in a variety of scenarios. The most common presentation is a full-thickness crack that originates at the coronet and extends distally. In these cases, the distal one-third of the hoof wall to the margin of the hoof capsule is usually solid. There is generally a proximal to distal concavity present in the dorsal hoof wall. The crack can be observed to open when the foot is unloaded and close when the load is applied to the foot. Full-thickness toe cracks are occasionally seen in horses with long-toe, low-heel conformation. This conformation loads the heels of the foot excessively, limiting growth at the heels and causing faster growth at the toe. This increased toe length creates excessive leverage on the hoof wall in the toe region during loading and especially at the breakover during the stance phase of the stride, predisposing to crack formation. Full-thickness toe cracks associated with this type of conformation usually begin as minor, incomplete cracks at the ground surface of the foot. If neglected, the cracks may propagate deeper and up the hoof wall and extend to the coronet. Lameness results if the crack fractures completely through the hoof wall, creating instability of the foot. It is not uncommon for toe cracks of this origin to be complicated by secondary white line disease.

Full-thickness toe cracks can also be seen in horses with excessively upright or clubfeet. In this scenario, the toe of the hoof may have a proximal to distal concavity and is loaded excessively. The coronet in the toe region may displace proximally as a result. Toe cracks as a result of this type of conformation/abnormal loading usually originate at or just below the coronet (in a manner similar to that of quarter cracks). The exact mechanism as to how a full-thickness toe crack occurs is unknown. As opposed to a quarter crack, a full-thickness toe crack will close when the load is placed on the hoof capsule and open when the weight is removed from the foot. There seems to be a reciprocal mechanism between expansion (or lack thereof) of the heels and movement of the defect at the coronet. At the origin of the toe crack, there will generally be a focal arch above the defect and one side of the crack may have an overriding appearance at the site of the defect (Fig. 5).

Full-thickness quarter and toe cracks occur almost exclusively in the front feet, presumably because front feet bear more weight than the hind feet.
MANAGEMENT OF QUARTER CRACKS

The management of full-thickness quarter cracks involves the identification and correction/management of balance issues and coronet displacement issues, unloading the injured region, stabilization of the hoof wall, and committed follow-up. In all cases, every effort should be made to identify the cause of the crack; if not, treatment success will be limited and the crack will likely reoccur. The assessment should begin with an evaluation of the horse’s limb and hoof conformation, noting any cause and effect of limb conformation on hoof loading and hoof capsule conformation/distortion that would predispose to crack formation. Base-wide and base-narrow conformation should be evaluated and, if present, the effects on hoof capsule loading and shape noted. The presence of excessively vertical heel quarters, rolled under heel quarters, and displaced coronets on the overloaded side of the hoof should be determined. A focal prominence of coronet displacement is often present just above the origin of the crack, indicating the point of maximal abnormal stress/strain. Zero-degree horizontal dorsopalmar and lateromedial radiographs centered on the solar margin of the distal phalanx can be helpful in evaluating hoof capsule/distal phalanx alignment. In horses with quarter cracks, there may be inappropriate medial to lateral orientation of the distal phalanx relative to the ground. If medial to lateral imbalance of the distal phalanx is present, it may match the coronet displacement (ie, the distal phalanx tilts in the same plane as the cornet displacement) or be opposite of the coronet displacement (ie, the distal phalanx tilts in the opposite plane of the coronet displacement) (Fig. 6). When the distal phalanx imbalance is opposite of the coronary band displacement, it is likely the result of disproportionate loading on one side of the hoof causing faster hoof growth on the side of the foot where the least amount of weight is borne and slower growth on the side where the most weight is borne.

Affected feet should be trimmed appropriately using the guidelines of a parallel hoof-pastern axis, center of articulation bisecting the weight bearing surface of the foot, and the heels of the hoof capsule extending to the base of the frog or trimming the heel area to ensure the frog and the hoof wall are on the same plane. If medial to lateral imbalance is present, the feet should also be trimmed in an attempt to realign the solar margin of the distal phalanx parallel to the ground. The amount of correction that is possible at any given trimming is dictated by the amount of sole depth available. It is acknowledged that complete correction of medial to lateral imbalances is rarely possible and that the imbalances tend to reoccur between trimming cycles. However, the practice of always

Fig. 5. (A) A full-thickness toe crack that shows focal displacement of the coronet at the origin of the defect. Note the dorsal hoof wall is solid distally at the ground surface. (B) Lateral view of same foot. Note the foot conformation, the concavity in the dorsal hoof wall, and the overriding margins of the crack.

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attempting to correct the imbalances will help correct and limit hoof wall distortion. It is critical that uneven growth/imbbalances are not ignored for successful long-term management. The fit of the shoe can be used to help improve the foot’s platform. For example, in quarter crack cases whereby the medial or lateral hoof wall is excessively straight or rolls under, the corresponding branch of the shoe should be fit as full as practical to provide appropriate symmetry to the ground surface of the foot.

The correction/management of soft tissue displacements (proximally displaced coronets), if present, is accomplished by unloading or floating the displaced region. If the situation permits, the horse’s shoes can be removed, the feet are trimmed such that the hoof wall at the heels and the frog are on the same plane, and the horse is then stood on a hard surface for 12 to 24 hours before trimming and shoeing. This practice can result in the affected side of the foot settling into a more acceptable conformation before completing the farriery. If a severe sheared heel hoof capsule distortion is present, the trimmed foot can be stood on some form of frog support and the foot placed in a soak bandage for 24 hours. This technique can produce a profound change in hoof shape in some cases. The specific farriery method used usually depends on personal preference. One method is to shoe the affected foot with a properly fit shoe with a rim pad (plastic or leather), minus the area of the pad that would contact the affected quarter and heel (Fig. 7A). This practice results in the region of the hoof with the displaced coronet being suspended (floated) approximately 0.125 to 0.25 in above the shoe. This suspension allows for the correction/improvement (settling) of the soft tissue displacement and also minimizes the external loads on the injured area. The gap between the shoe and the foot is filled with a small piece of weather stripping to prevent dirt/debris from accumulating in the floated region (see Fig. 7B, C). The solar surface of the foot is filled with a liquid urethane hoof packing material (Equi-Pak, Vettec Hoof Care Products, Oxnard, California) to help support the digit and minimize internal stresses on the crack. The urethane material is applied to ground level everywhere except in the region of the affected heel/quarter where it is only applied to shoe level. Applying the hoof packing in this manner maintains the float of the affected heel/quarter region.
A second method involves a double-trimming technique. The affected foot is first trimmed appropriately as described earlier and then, before attaching the shoe, a second trim is performed under the proximally displaced quarter/heel. The second trim begins at the ipsilateral toe and increases in depth toward the heel. The amount of heel that can be taken off in the second trim depends on the sole depth in the quarter/heel area. Ideally, the amount of heel removed corresponds to the amount of proximal displacement of the coronet. The foot is then shod with a symmetrically fitted wide web steel straight bar shoe, creating a space that resembles a wedge between the affected quarter/heel and the shoe (Fig. 8). If there is not enough sole depth under the affected heel for the second trim, the wall can be raised with a full leather pad. When a full pad is used, impression material (Equilox Pink, Equilox International, Pine Island, Minnesota) is placed beneath the pad to fill the frog sulci in the palmar section of the foot from the apex of the frog palmarly, except under the displaced heel. A third potential method used by one author (I.H.M.) on racehorses for floating the affected quarter/heel region is to trim the affected foot appropriately and then use a shoe that has a 2-component polyurethane rim pad affixed to it (Yasha Shoe, Tenderhoof Solutions, Ontario, Canada). The polyurethane in the heel area of the shoe is significantly softer than the polyurethane covering the rest of the shoe and, therefore, functionally unloads and floats the affected heel (Fig. 9).
If a horse with a full-thickness quarter crack is being taken out of work, the crack will not be repaired during the initial farriery. When the horse is presented for a subsequent reset, there should be significant new solid growth at the coronet above the defect. This growth would indicate that the initial farriery is effective in unloading the affected heel quarter. At this time, the crack can be repaired or allowed to grow out. If the crack is to be repaired, the defect should be debrided/explored with a motorized grinding tool or hoof knife, removing obviously undermined and diseased hoof wall. Exploration often reveals wall damage and undermining that exceeds initial visual appreciation. Care should be taken not to traumatize the dermis during debridement. No (or only occasional pinpoint) hemorrhage should occur during debridement. After debridement,

Fig. 8. (A) Steel straight bar shoe. Note the nails placed only in the toe area on the affected side (B) Lateral view showing hoof wall lowered from toe quarter to heel on second trim. Note space between the hoof wall and the shoe. (C) Palmar view showing the space below the sheared heel to allow the heel to settle distally.

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Fig. 9. (A) Yasha shoe. Note 2-component polyurethane rim pad. (B) Shoe applied functionally floating the heel region.
the crack defect should be treated with a topical disinfect/drying agent, such as 2% Tincture of Iodine or Thrush Buster (Delta Mustad Hoofcare, Lake Forest, Minnesota), at least once daily.

Ideally, horses with full-thickness quarter cracks should be taken out of work and allowed time for the inflammation to resolve, the dermal portions of the crack to heal, existing hoof distortions and soft tissue displacements to be corrected/improved, and the cracks to begin to be replaced by new wall before they are repaired. However, veterinarians and farriers often encounter situations when it is important for horses with full-thickness quarter cracks to continue to train and compete. In these cases, the repair/stabilization of the crack is often necessary before hoof distortions and soft tissue displacements can be corrected and sometimes before the dermal portions of the crack have healed/dried out sufficiently. Several techniques exist for repairing and allowing continued treatment of the crack in these cases. Fully addressing the hoof distortion and soft tissue displacement issues should be emphasized as soon as the horse can be taken out of work.

The first author’s (R.S.P.) preferred technique for repairing quarter cracks is to plate the crack with a composite of polymethylmethacrylate adhesive (Equilox, Equilox International, Pine Island, Minnesota) and a polymeric fabric (Fig. 10). Before plating the crack, the hoof wall must be prepared to accept the adhesive (cleaned/sanded) and povidone iodine ointment (or another similar substance) applied into the crack bed to prevent the adhesive from entering the crack. The type and number of layers of fabric used to construct the plate will depend on the anticipated strength needed. For most cracks, 3 layers of polymethylmethacrylate saturated polyester/vectran fabric (Sound Horse Technologies, Unionville, Pennsylvania) provide sufficient strength. The plate should extend from the coronet to the distal surface of the hoof wall and at least 1.5 in dorsal and palmar from the edges of the crack. Each side of the polyester/vectran fabric is saturated with adhesive. The layers are then stacked and pressed together with a roller to expel excess adhesive. The plate is applied and allowed to cure with the foot unloaded so that the crack is stabilized in a neutral position. Small holes are then drilled proximally and distally through the repair into the crack defect to vent the crack or to allow continued treatment beneath the repair. The repair should be completely removed and reapplied (from the distal wall to the coronet) at least every other shoeing to minimize localized stress at the top of the repair. Complete reconstruction of the crack (filling the crack bed with adhesive as well as plating over the defect) may eventually be performed but only after the crack bed is completely dry. In many horses, a residual defect will remain apparent after the crack has grown out. This defect is manifested by a faint line or a slight inversion of the wall in the area of the previous crack and may represent permanent injury to the germinal tissues of the hoof wall as

![Fig. 10.](image-url)
a result of the original crack. In these cases, it is recommended to maintain the horse with a polymethylmethacrylate/polymeric fabric plate over the affected area whenever the horse is in training to reduce the risk of repeated cracks.

The second and third authors’ (S.E.O. and I.M.) preferred technique for stabilizing quarter cracks involves inserting an implant comprising stainless steel wires first and then reinforcing the wires with a patch consisting of a mix of fiberglass strands and polymethylmethacrylate adhesive (Fig. 11).11,12 Two sets of paired holes (0.25 in apart) are drilled perpendicular to the crack defect on each side of the crack, beginning at least 0.5 in from the margin of the defect and ending in the crack defect across from each other. The drilling is performed using a Dremel tool (Dremel, Racine, Wisconsin) and a 0.0469-in cobalt drill bit. A cobalt bit is used because it will not bend easily, which deters it from going in an undesired direction. Once the holes are drilled, the wire sets (Tenderhoof Solutions, Ontario, Canada) are inserted in palmar-to-dorsal and dorsal-to-palmar directions into the crack defect. The wires are then pulled tight and bent outwards. The wires go through steel tabs that lie against the hoof wall so that they will not pull through the wall. A drain is then created by placing a small amount of medicated putty (Keratex Hoof Putty, Keratex, Wiltshire, United Kingdom) into the crack bed and then pressing a thin piece of tubing or plastic string into the putty that exits at the top and bottom of the crack. The ends of the opposing wires are then joined together and twisted until resistance is felt. The horse should not show discomfort caused by overtightening of the wires. The excess wire is cut off at the top of the twist. Polymethylmethacrylate adhesive mixed with strands of fiberglass (Equilox, Equilox International, Pine Island, Minnesota) is then applied over the wires onto the hoof wall. It is thought that the composite mixed with strands of fiberglass add strength to the repair and provides better adhesion to the hoof wall. Care must be taken that the composite patch does not extend beyond the distal margin of the hoof wall to prevent this section of the hoof from being unloaded. On completion of the cure cycle, the drain is removed, allowing for continued treatment beneath the repair if necessary.

MANAGEMENT OF TOE CRACKS

In horses with toe cracks associated with long-toe, low-heel conformation, a radiographic evaluation often displays divergence of the distal dorsal hoof wall from the dorsal surface of the distal phalanx, excessive digital breakover, and a flat to negative distal phalanx palmar angle (Fig. 12A). The management of full-thickness toe cracks in

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Fig. 11. (A) Quarter crack repair using stainless steel wires (implant). (B) Completed repair. Note the opening dorsally that can be used to flush interior of repair if necessary.
horses with this type of conformation begins with trimming the feet using the guidelines outlined earlier. The dorsal surface of the hoof wall should be dressed back to align with the dorsal surface of the distal phalanx. The feet should be shod with some form of enhanced breakover to reduce leverage on the toe. The shoes should also be fit to provide as much palmar support as practical to improve the foot’s base of support and to encourage more appropriate hoof growth (see Fig. 12B).

In horses with toe cracks associated with an upright or clubfoot hoof conformation, the feet should be trimmed to establish parallel hoof-pastern axes and to shift the load away from the toe and onto the palmar section of the foot. This process can be accomplished by beginning the trim in the middle of the foot and trimming the foot in a tapered fashion toward the heels, which will create 2 planes on the ground surface of the foot. Any concavity in the dorsal hoof wall should be backed up from the dorsal surface. The feet should be shod with appropriately fit shoes with ample breakover created in the toe of the shoe. Care should be taken to prevent excess shoe pressure in the toe region.

The stabilization of toe cracks can be accomplished via several techniques. The first author (R.S.P.) prefers to stabilize toe cracks with polymethylmethacrylate adhesive saturated polymeric fabric plates (Fig. 13) using the same technique and principles.

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**Fig. 12.** (A) Lateromedial radiograph of a horse suffering from a full-thickness toe crack. (B) Proper trim and shoe fit of same foot.

**Fig. 13.** (A) Completed repair of a full-thickness toe crack extending the length of the dorsal hoof wall using polymethylmethacrylate adhesive and polymeric fabric composite (B) Lateral view.
as described for quarter crack repair. Further stabilization of the foot (minimizing
internal movement of the digit) is achieved by the use of some type of support shoe
or heel plate shoe with impression material or via polyurethane sole support materials
(EquiPak, Vettec Hoof Care Products, Oxnard, California). The second author (S.E.O.)
prefers to stabilize toe cracks with a metal plate that bridges the crack and that is
anchored on each side of the crack with screws. A lightweight, approximately $3 \times 8$

\text{cm}

metal plate (steel, aluminum, or brass) is used. A 0.1406-in drill bit is used to
make as many holes in the plate as necessary, with the holes positioned at least 0.5
cm apart and away from the crack. The plate is bent to conform to the contour of
the coronary band and the curvature of the hoof wall and is positioned approximately
1 cm distal to the coronary band. The plate is applied with #6 0.375-in or smaller
(depending on the thickness of the hoof wall) sheet metal screws and a screwdriver.
At least 4 screws should be placed on each side of the crack for a secure application
\textbf{(Fig. 14)}. It is extremely important to attach the plate with the foot off of the ground or
in the unloaded position. This placement ensures that the defect is affixed in the open
position allowing better alignment and reducing any compression on the dermal
papillae producing horn tubules.

\textbf{SUMMARY}

Quarter and toe cracks that result in the loss of the structural integrity of the hoof wall
are not uncommon and usually manifest in lameness. From the perspective of patho-
genesis and stabilization, these cracks should be thought of as wall fractures. From
the perspective of healing, the cracks can only be eliminated by new, stable growth.
Successful management involves identifying and addressing the underlying causes,
stabilization of the foot, and committed follow-up to prevent reoccurrence.

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\textbf{Fig. 14. (A) Toe crack repaired with a metal plate and screws. Note the plate is shaped to
reflect the contour of the coronary band. (B) Same repair technique using a metal plate.}