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Ultrasonographic evaluation of wound healing in ovariohysterectomized dogs

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i5j.8528>**Abstract**

The present investigation was designed to characterize the temporal progression of abdominal wound healing following ventral abdominal surgery in dogs and to delineate ultrasonographic alterations during the reparative phase using B-mode ultrasonography. Six dogs of varying breed, age, and sex, subjected to ventral midline laparotomy for diverse clinical indications, were included in the study. Imaging was performed using a real-time B-mode ultrasound system (MINDRAY DC-7) equipped with a 10 MHz linear array transducer.

Ultrasonographic assessments were conducted in longitudinal planes. Longitudinal scans were performed parallel to the incision line in the same orientation. Baseline imaging was performed approximately 24 hours pre-operatively (day 1), followed by serial evaluations at 3rd, 7th, 14th and 28th day intervals during the hospitalization period.

In the early post-operative phase, ultrasonographic evaluation of the abdominal skin and muscle revealed an ill-defined hypoechoic region with acoustic shadowing artefacts, consistent with acute inflammatory changes, tissue edema and increased wound thickness associated with surgical trauma. A significant ($p \leq 0.05$) increase in both muscle and skin wound thickness was observed among the groups during the post-operative period, particularly on days 3 and 7 for muscle thickness and on days 3, 7 and 14 for skin thickness, reflecting the acute inflammatory response following tissue injury. As healing progressed, the lesion maintained a predominantly hypoechoic echotexture with gradual development of a central echogenic component, indicating early granulation tissue formation along with persistent acoustic shadowing. By day 14 post-surgery, the wound exhibited a heterogeneous and disorganized echogenic architecture, suggestive of ongoing tissue remodeling. By day 28, the lesion appeared markedly hyperechoic and disorganized, indicating advanced fibroplasia, collagen deposition and maturation of the healing tissue matrix.

The findings of this study underscore the utility of B-mode ultrasonography as a non-invasive and reliable modality for sequential monitoring of surgical wound healing. Although both imaging planes provided diagnostically relevant information, transverse scanning was subjectively found to be more practical and reproducible for evaluation of the surgical site.

Keywords: B-mode ultrasonography, wound healing, laparotomy, canine, echogenicity

Introduction

Ultrasonography enables the detection of subtle variations in the acoustic impedance of soft tissues and, consequently, serves as a highly sensitive modality for the identification and characterization of fluid accumulations and soft tissue masses.

Ultrasonography is a safe, non-invasive, radiation-free and portable method of imaging, which makes it very suitable for a clinical use (Pipers, 1982) [15]. It has been developed for objective wound assessment (Wendelken *et al.*, 2003) [21] and with the advent of high-frequency B-scan ultrasound, it is now possible to monitor and assess the healing of wounds in the deeper layers of the skin (Hoffman *et al.*, 1994). Ultrasound is being utilized to see most structures of the body in veterinary medicine. Lower-frequency ultrasound (3-5 MHz) for imaging deeper skin structures or thick subcutaneous tissues. In contrast, higher frequencies (7.5-10 MHz) provide better resolution for superficial layers like the epidermis and dermis (Fornage and Deshayes, 1986) [7]. Ultrasonography (USG) is being increasingly used in the postoperative assessment of incisional wounds for the purpose of fluid and gas accumulations analysis, as well as muscle fiber integrity (Trout *et al.*, 1994) [20].

Ultrasonography is a valuable, non-invasive imaging tool in dermatological research that provides measurable parameters for accurate diagnosis and monitoring. Increased epidermal water content associated with inflammation appears as echo-deficient areas on ultrasound. It is also considered safe for both animals and operators due to minimal sound wave absorption (Rallan and Harland, 2003) [17]. The current study has been performed for assessing skin and muscle thickness as well as echogenicity and echotexture of abdominal skin and muscle during healing process after abdominal surgical procedure. The study was conducted with the purpose of detecting any changes in the healing process using B-mode ultrasonography.

Materials and Methods

Animal and preparation technique

Six dogs of different breeds, sex and age referred to the Department of Veterinary Surgery and Radiology at College of Veterinary Science and Animal Husbandry, Rewa, were used in this study. The dogs had undergone ventral abdominal surgery for animal birth control. The surgery was carried out on the ventral abdominal midline (ovariohysterectomy). The ventral abdominal area had been prepared earlier for abdominal surgery.

A real-time B-mode ultrasound machine (MINDRAY DC-7) connected with a 10 MHz linear array transducer was used in this study. A video recorder (MINDRAY) was connected to the scanner to record the scanned images. The animal was laid on the table on dorsal recumbency during scanning. The ultrasonographic examination was done longitudinally across the ventral abdominal midline (wound) from cranial to caudal was done along the wound (incision site) from cranial to caudal. Initial scanning was carried out on day one (approximately 24 hours) pre-operation. Subsequent scans were carried out on the 3rd, 7th, 14th and 28th day. An ultrasonographic examination was then carried out when the animals returned for wound assessment and removal of suture material. The scanned images for each of the cases were recorded during scanning on a super VHS videotape for revision at a later date. The best images were printed during review and labeled accordingly.

Results and Discussion

Skin and Muscle Thickness

A significant ($p \leq 0.05$) increase in both skin and muscle wound thickness was observed (table 01) during the early post-operative period, particularly on days 3 and 7 for muscle thickness and on days 3, 7 and 14 for skin thickness. The increase in wound thickness during the initial healing phase may be attributed to acute inflammatory reactions associated with surgical trauma, including edema, hemorrhage, inflammatory exudation and cellular infiltration.

Muscle wound thickness reached its maximum on day 3 post-operatively, likely due to muscle fiber disruption, tissue edema and inflammatory cell accumulation at the surgical site. Thereafter, a gradual decline in muscle thickness was observed (table 01) throughout the study period, indicating progressive resolution of inflammation and advancement of tissue remodeling. By day 28, muscle thickness values had nearly returned to baseline levels, suggesting restoration of normal tissue architecture.

Similarly, skin wound thickness showed a significant increase during the early post-operative period (table 01),

with the highest values recorded on day 3. This increase may be associated with increased vascular permeability, inflammatory infiltration and accumulation of tissue fluids during the inflammatory phase of wound healing. Subsequent reduction in skin thickness indicated regression of edema and progression toward tissue repair and remodeling. Near-normal skin thickness observed on day 28 suggested satisfactory healing and structural reorganization of the tissue.

Table 1: Mean $\pm$ SE values of muscle and skin wound thickness (cm) at different time intervals

Thickness	Day 0	Day 3	Day 7	Day 14	Day 28
SKIN	0.30 $\pm$ 0.02	0.63 $\pm$ 0.01	0.57 $\pm$ 0.01	0.47 $\pm$ 0.01	0.37 $\pm$ 0.02
MUSCLE	0.51 $\pm$ 0.02	1.00 $\pm$ 0.04	0.83 $\pm$ 0.04	0.72 $\pm$ 0.02	0.60 $\pm$ 0.02

The ultrasonographic findings of the present study are consistent with previous reports describing increased wound thickness during the inflammatory phase followed by gradual normalization during healing and remodeling. Fornage and Deshayes (1986) [7] reported similar ultrasonographic changes in acutely injured muscles characterized by increased thickness and hypoechoic appearance during inflammation. Wilson *et al.* (1989) [22] and Zuki and Boyd (2003) [23] also observed progressive reduction in tissue thickness during healing due to resolution of edema and restoration of tissue integrity.

High-frequency ultrasonography has been widely recognized as a sensitive and reliable technique for evaluation of soft tissue healing. Cannon and Puchalski (2008) [2] emphasized its utility in monitoring musculotendinous injuries in dogs, while Pillen *et al.* (2009) [14] reported that ultrasonographic changes in muscle appearance correspond closely with tissue damage and fibrosis. Similar observations regarding wound thickness changes during healing were also reported by Trout *et al.* (1994) [20], Mantis *et al.* (2014) [12], Mallick *et al.* (2017) [11] and Diana *et al.* (2004) [4].

Echogenicity and Echotexture

In addition to quantitative measurements, qualitative ultrasonographic parameters such as echogenicity and echotexture provided important information regarding tissue healing dynamics. Early post-operative wounds generally appeared hypoechoic to anechoic due to edema, hemorrhage and inflammatory exudation, whereas progressive healing was characterized by gradual transition toward hyperechoic and homogeneous tissue patterns associated with granulation tissue formation, collagen deposition and tissue remodeling.

At the pre-operative stage (day 0), the skin appeared as a thin hyperechoic epidermal line with homogeneous moderately echogenic dermis, while the muscle layer demonstrated organized parallel echogenic striations and homogeneous echotexture, indicating normal tissue architecture.

On day 3 post-operatively, the skin appeared mildly hypoechoic with heterogeneous echotexture, reflecting edema and inflammatory exudation during the acute inflammatory phase. The muscle layer exhibited heterogeneous echotexture with hyperechoic areas interspersed with anechoic fluid pockets, indicating hemorrhage, edema and inflammatory infiltration at the surgical site.

By day 7, the skin demonstrated comparatively increased echogenicity with moderately homogeneous echotexture, suggesting progression toward the proliferative phase of healing and granulation tissue formation. However, the muscle layer remained mildly heterogeneous and comparatively hypoechoic, indicating persistence of inflammatory activity and incomplete muscle fiber organization.

On day 14, the ultrasonographic appearance of the skin remained comparable to that observed on day 7, whereas the muscle layer continued to exhibit heterogeneous echotexture with small residual anechoic pockets, suggesting ongoing tissue remodeling and delayed resolution of inflammation.

By day 28, the skin appeared nearly isoechoic and homogeneous, approaching normal ultrasonographic architecture. In contrast, the muscle layer remained mildly hyperechoic with residual heterogeneity, which may indicate fibrous tissue organization and incomplete maturation of regenerating muscle fibers.

The sequential ultrasonographic changes observed in the present study are in agreement with previous reports by Mallick *et al.* (2017) ^[11], Mantis *et al.* (2014) ^[12] and Fornage and Deshayes (1986) ^[7], who described normal abdominal tissues as homogeneous and organized in

appearance, while inflamed tissues appeared hypoechoic and heterogeneous. Similar inflammatory phase alterations were also reported by Wilson *et al.* (1989) ^[22], Zuki and Boyd (2003) ^[23], Singh *et al.* (2020) ^[19] and Rajasekar *et al.* (2022) ^[16].

The gradual transition from heterogeneous to homogeneous echotexture observed during later stages of healing corresponded with fibroblast proliferation, collagen deposition and tissue maturation. Similar findings have been described by Wilson *et al.* (1989) ^[22], Mallick *et al.* (2017) ^[11] and Rajasekar *et al.* (2022) ^[16], who reported that improvement in echogenicity and organization of echotexture are indicative of progressive wound healing and collagen maturation.

Persistent mild hyperechogenicity and heterogeneous echotexture observed in muscle tissue on day 28 may reflect ongoing fibrosis and delayed maturation of healing tissue. Comparable observations were reported by Olerud *et al.* (1990) ^[13] and Laine *et al.* (1985) ^[10], who associated disorganized hyperechoic structures with fibrosis and scar tissue formation. Overall, the present findings support the usefulness of high-frequency B-mode ultrasonography for objective monitoring of wound healing progression and tissue remodeling in dogs.

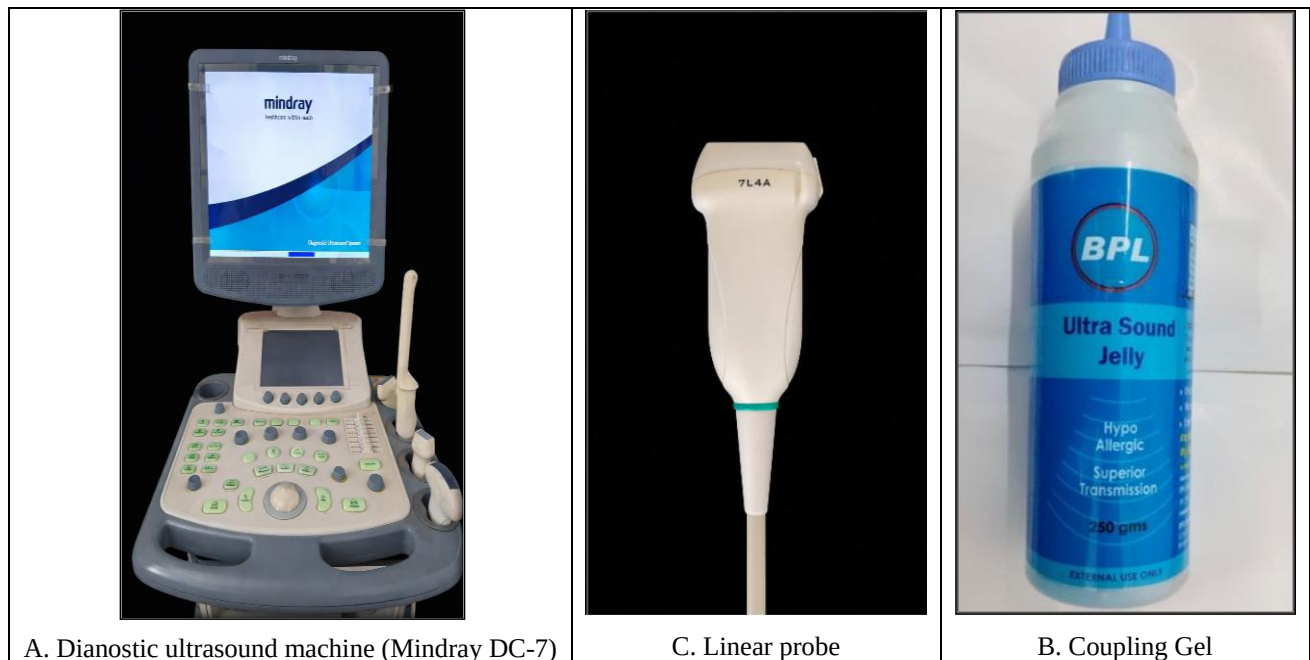


Fig 3: Mean $\pm$ SE values of skin wound thickness (cm) at different time intervals

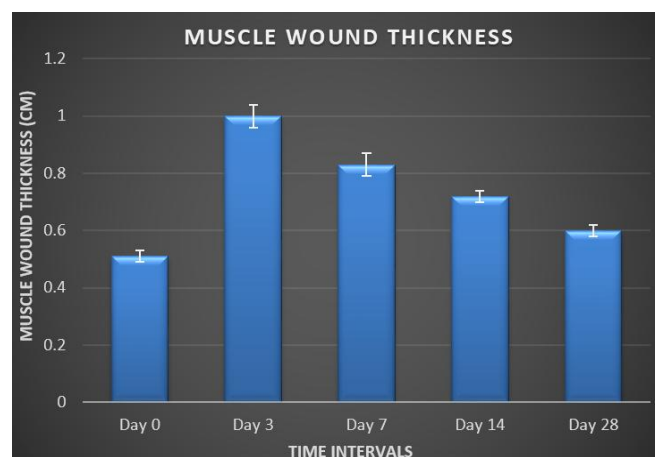


Fig 4: Mean $\pm$ SE values of Muscle wound thickness (cm) at different time intervals

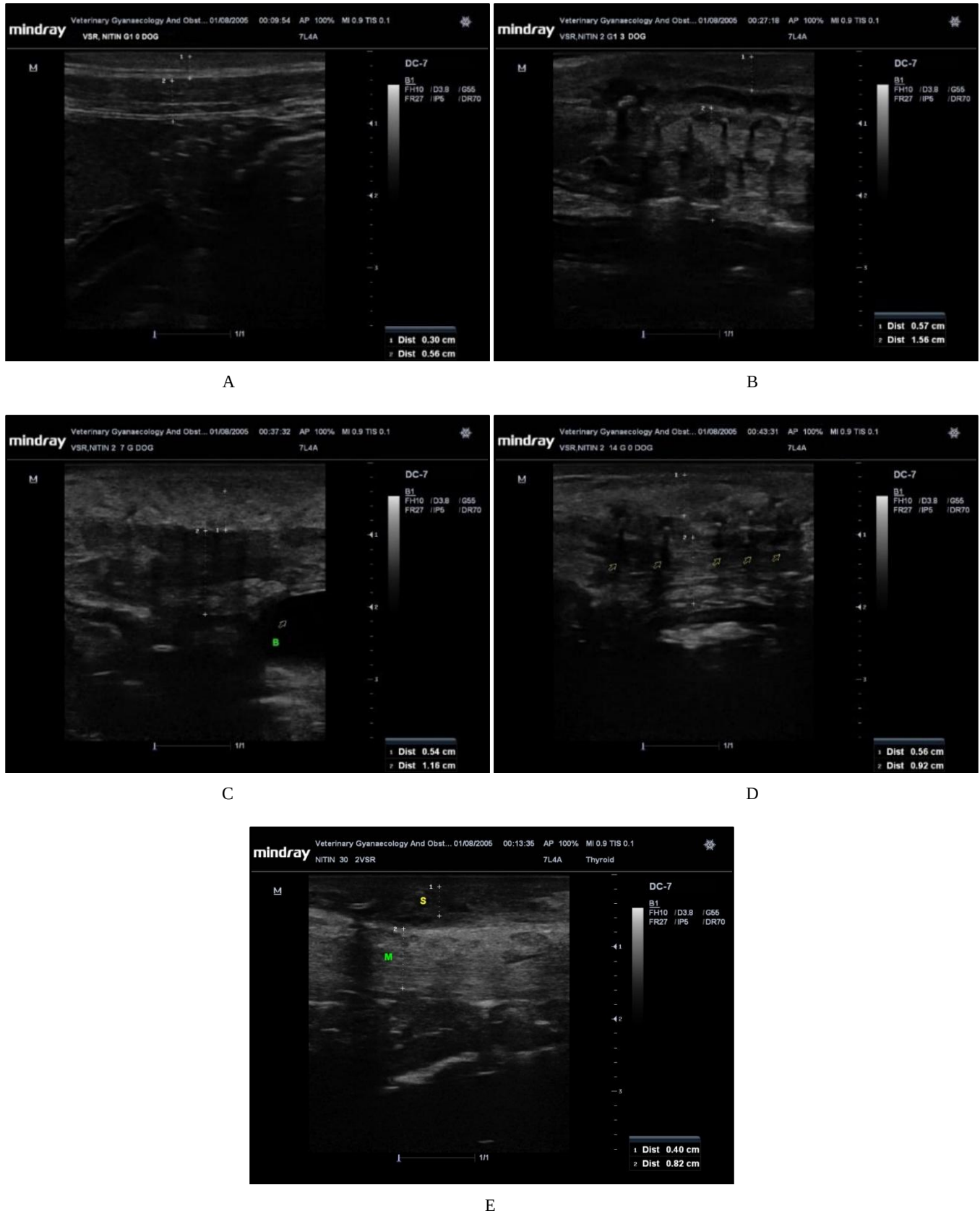


Fig 2: Ultrasonographic images (A) day 0 (B) day 3 (C) day 7 (D) day 14 and (E) day 28

Conclusion

The present study concluded that B-mode ultrasonography is a reliable, non-invasive and effective tool for monitoring abdominal wound healing in dogs following ventral midline surgery. Significant early increases in skin and muscle thickness were observed due to inflammation and edema, followed by gradual reduction during tissue repair and

remodeling. Sequential changes in echogenicity and echotexture corresponded well with different stages of wound healing, including inflammation, granulation tissue formation and collagen maturation. Overall, high-frequency ultrasonography proved useful for objective assessment of soft tissue healing and post-operative wound evaluation in veterinary practice.

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