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Survey of veterinarians' usage and satisfaction with intra-articular polyacrylamide gel in horses

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ABSTRACT

Polyacrylamide gel is increasingly used in equine veterinary medicine for osteoarthritis and other joint disorders. This study aimed to document the indications, treatment protocols, rehabilitation plans, outcomes, and satisfaction with intra-articular polyacrylamide gel in horses, as reported by equine veterinarians. An online questionnaire was distributed to practitioners through the European and American Colleges of Veterinary Sports Medicine and Rehabilitation mailing lists, social media, and direct contact. Of 197 respondents, 160 completed the survey, forming the basis for the descriptive statistical analysis. The primary indications for polyacrylamide gel use were chronic synovitis/osteoarthritis (87.1%) and failure of prior joint treatment (83.6%). Treatment protocols, post-treatment rehabilitation plans, and clinical outcomes varied among practitioners and respondent groups based on experience and disciplinary focus (assessed using automated A/B or Kruskal-Wallis with post-hoc Dunn's test). Most respondents reported return to full exercise from week 4 post-treatment. Complications, worsening, or lack of improvement following treatment were rare, while complete recovery, partial improvement, or transient improvement were commonly observed. Median satisfaction score among respondents was rated 8/10. As expected with the study design, the responses limited detailed insights into individual experiences and may reflect response bias, with most respondents being specialized or focused on equine orthopedics. Despite these limitations, the survey highlights a general good satisfaction with intra-articular polyacrylamide gel, mainly for chronic synovitis/osteoarthritis and use after failure of prior joint treatment, with low reported complication rates and favorable outcomes. These findings support developing standardized guidelines for intra-articular polyacrylamide gel treatment and post-treatment rehabilitation protocols in horses.

1. Introduction

In recent years, polyacrylamide gel has been increasingly used in equine veterinary medicine to treat osteoarthritis and other joint disorders [1]. This hydrogel consists of water and cross-linked polyacrylamide, forming a biocompatible, non-degradable matrix [2–4]. In horses, the main intra-articular polyacrylamide gel products used are ArthramidVet® (Contura International A/S, Soeborg, Denmark) and Noltrex®Vet (Nucleus ProVets LLC, Kennesaw, Georgia, USA), which contain 2.5% and 4.0% of polyacrylamide, respectively. Furthermore, Noltrex®Vet contains silver ions, which are supposed to act as antimicrobials [5], where ArthramidVet® does not contain silver ions. A 2.5% polyacrylamide gel induced a typical macrophage-driven foreign body response in healthy equine joints without fibrosis or mineralization [6] and the positive effects of reduced pain and inflammation arise from its mechanical action through integration into the synovial membrane, leading to reduced overall joint capsule stiffness [1,3,4,7]. On the other hand, 4.0% polyacrylamide gel was engineered to mimic the viscoelastic properties of normal synovial fluid, effectively lubricating damaged cartilage surfaces [8,9].

De Sousa et al. (2020) stated that robust evidence supporting using polyacrylamide gel for equine osteoarthritis remains limited [10]. However, recent clinical and experimental trials have shown positive outcomes, including reduced lameness, high safety improved joint range of motion, and prolonged functional improvement in horses with osteoarthritis [11–18].

Most research on intra-articular polyacrylamide gel treatment in horses is based on treatment with a 2.5% polyacrylamide gel [11–17], which has demonstrated its effectiveness in reducing clinical signs of lameness and pain caused by the degenerative processes of joint disease

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[14]. In clinical studies using a 4.0% polyacrylamide gel, the treatment appeared safe in normal equine joints [17], and lameness was decreased in 82.1% of horses with naturally occurring osteoarthritis [18]. The present study aimed to assess the indications, treatment protocols, post-treatment rehabilitation plans, clinical outcomes, and overall satisfaction with intra-articular polyacrylamide gel in horses, as reported by equine veterinarians.

2. Material and methods

2.1. Experimental setup

The online survey platform SurveyMonkey® (SurveyMonkey Europe UC, Dublin, Ireland; www.surveymonkey.com) was used to design and distribute the questionnaire to practitioners. Respondents were targeted through veterinary community social media (Facebook), using private messaging groups of equine veterinarians, direct contact with peers, and the mailing lists of the European and American Colleges of Veterinary Sports Medicine and Rehabilitation and of wholesale Vetrinova GmbH. After being informed, all respondents agreed that their data would be anonymously collected and analyzed with the aim of publishing the results. The average time to complete the survey was nine minutes.

2.2. The questionnaire

The survey consisted of 34 unique questions, provided in Supplementary File (S1). Questions 1 to 5 gathered demographic information, years in practice, and details about the veterinary caseload of respondents. Question 7 assessed whether they had ever used intra-articular polyacrylamide gel in horses. Only respondents who answered "yes" to this question were directed to additional questions about their experience with polyacrylamide gel. If respondents answered "no" to Question 7, questions about polyacrylamide gel were skipped, and they proceeded to Question 33. Respondents who used polyacrylamide gel and answered "yes" to Question 29 (whether they had experienced complications using it) were asked Questions 30–32 about these complications. If they answered "no" to Question 29, they proceeded to Question 33.

2.3. Data analysis

Only complete questionnaires were included in the data analysis. The data were analyzed using the automated SurveyMonkey® software. Differences between groups of respondents were calculated using either the automated A/B test (SurveyMonkey® software) or the Kruskal-Wallis with post-hoc Dunn's multiple comparisons test (Prism 10.4.0 for macOS, GraphPad Software, Boston, MA, USA) for non-normal distributed data (assessed by a Shapiro-Wilk test). A $p<0.05$ was considered significant. Overall results are presented using descriptive statistics.

3. Results

3.1. Descriptive information of respondents

This survey gathered 197 responses between November 1st and 24th, 2024, of which 160 completed the questionnaire. Respondents were practicing in Germany (n=59), the United States (n=27), the Netherlands (n=18), the United Kingdom (n=12), Australia (n=5), Norway (n=5), Ireland (n=5), Austria (n=4), France (n=4), Poland (n=4), Denmark (n=3), the United Arab Emirates (n=2), Sweden (n=2), Slovenia (n=1), Czech Republic (n=1), and New Zealand (n=1). Descriptive details about veterinarians' experience, caseload, and disciplinary focus are outlined in Table 1.

Table 1
Summary of answers to Questions 1–5 about the 160 respondents' experience, caseload, and disciplinary focus.

Questions and answers	Number of responses	% of total responses
Years of experience as veterinarian		
< 5 years	15	9.4%
5–10 years	34	21.3%
11–20 years	59	36.9%
> 20 years	52	32.5%
Percentage of equine patients within caseload		
> 75%	154	96.3%
50–75%	4	2.5%
< 50%	2	1.3%
Percentage of orthopedic cases within equine caseload		
> 50%	130	81.3%
25–50%	24	15.0%
< 25%	6	3.8%
Disciplinary focus		
Sports horses	143	89.4%
Racehorses	36	22.5%
Leisure horses	82	51.3%
Western performance horses	24	15.0%
Endurance horses	6	3.8%
Others	6	3.8%

3.2. Reported use of polyacrylamide gel in horses

3.2.1. Availability of and experience with polyacrylamide gel

Most respondents (75.6%) reported that polyacrylamide gel was available to them, while 16.8% stated it was not, and 7.5% were unsure. Of the 160 complete questionnaires, 88.1% of respondents had experience using intra-articular polyacrylamide in horses. ArthramidVet® was the most commonly used product (98.6%), followed by Noltrex®Vet (42.1%), Aquamid® (10.0%; Contura International A/S, Soeborg, Denmark), and other products (0.7%). Over half of the respondents reported using polyacrylamide gel less than once per month (33.6%) or only once or twice per month (32.9%). Only 9.9% of respondents used polyacrylamide gel in more than ten cases per month. The median percentage of polyacrylamide gel injections compared to the total number of joint treatments was 5% (range: 0-100%).

3.2.2. Indications and contraindications

The main indications for the use of intra-articular polyacrylamide gel were chronic synovitis/osteoarthritis (87.1%) and failure of prior joint treatment (83.6%). These indications were also the primary reported reasons for choosing polyacrylamide gel over other intra-articular therapies (55.0% for chronic synovitis/osteoarthritis and 64.3% after failure of prior joint treatment).

The most commonly reported contraindications were acute joint pain (56.4%) and preventative joint treatment (34.3%). "Septic joints" or "suspected septic joints" were often mentioned as other contraindications (Fig. 1).

3.2.3. Treated joints and volumes

Respondents reported treating various joints with polyacrylamide gel, primarily fetlock joints (89.3%), distal interphalangeal joints (85.0%), stifle joints (60.0%), proximal interphalangeal joints (58.6%), carpal joints (55.0%), and tarsal joints (52.1%). For the smaller joints (*i.e.,* distal interphalangeal joints, proximal interphalangeal joints, and cervical facet joints), more than half of the respondents used a 1 ml volume. For fetlock joints and carpal joints, respondents mainly used 1 to 2 ml volumes. For stifle joints and sacroiliac joints, most indicated primarily using 2 to 4 ml (Table 2).

3.2.4. Treatment protocols

Almost half of the respondents (46.4%) reported using

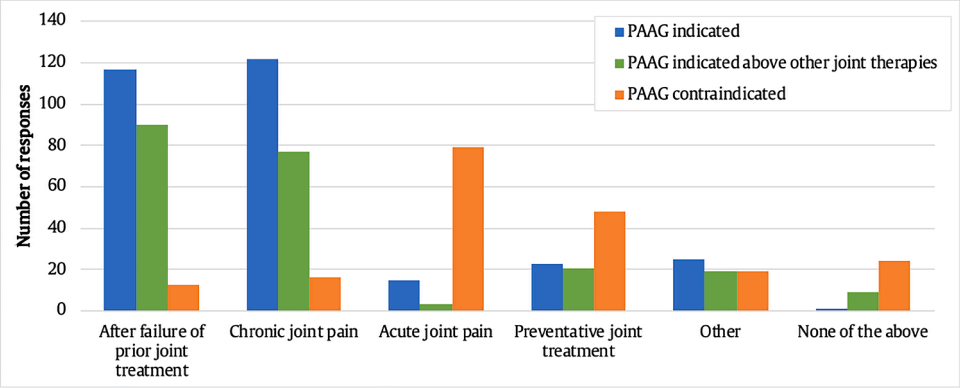

Fig. 1. Results of 140 respondents' answers to Questions 11 and 13 about the indications and contraindications for using intra-articular polyacrylamide gel (PAAG) in horses.

Table 2
Answers of 140 respondents to Question 15 about which volumes of polyacrylamide gel they were using in various joints.

	% of total responses			
Joints	*1 ml*	*2ml*	*3ml*	*4ml*
Distal interphalangeal joint	69.4%	29.0%	6.5%	0.0%
Proximal interphalangeal joint	80.9%	18.0%	2.3%	0.0%
Fetlock joint	47.2%	50.4%	8.0%	3.2%
Carpal joint	44.4%	50.6%	7.4%	8.6%
Tarsal joint	69.2%	33.3%	5.1%	1.3%
Stifle joint	12.1%	44.0%	29.7%	30.8%
Cervical facet joint	88.0%	16.0%	0.0%	0.0%
Sacroiliac joint	12.5%	25.0%	37.5%	25.0%
Other joint	46.7%	40.0%	13.3%	0.0%

polyacrylamide gel as a sole therapy, while 40.7% used it as a maintenance treatment at several-month intervals. Repeated injections, either as a standard procedure or after a poor response to the initial polyacrylamide gel treatment, were less frequently selected (12.1% and 18.6%, respectively).

Most respondents (49.3%) never combined polyacrylamide gel administration with concurrent intra-articular medications, while 47.1% reported administering corticosteroids concurrently. Corticosteroids were also most often used as a successive treatment of polyacrylamide gel (58.6%), whereas 25.7% did not use any other medication successively (sole therapy). Other combined intra-articular medications (either concurrently or successively) included antibiotics, joint anesthesia, hyaluronic acid, platelet-rich plasma, interleukine-1-receptor antagonist protein, autologous protein solution, mesenchymal stem cells, and polysulfated glycosaminoglycan (PSGAG) (Fig. 2).

Systemic bisphosphonates (38.6%), PSGAG (8.7%), and nonsteroidal anti-inflammatory drugs (NSAIDs; 7.9%) were often selected as combined therapies with intra-articular polyacrylamide gel treatment. However, 25.7% of respondents reported never combining polyacrylamide gel with systemic treatment.

3.2.5. *Rehabilitation protocols and follow-up*

Post-treatment rehabilitation plans varied between respondents. Most reported prescribing box rest on days 1–3, followed by controlled hand-walking on days 4–6 and week 2 (Fig. 3). In week 3, the most commonly selected activities were "reduced ridden exercise" and "full exercise." From week 4 onward, most respondents chose "full exercise," while "reduced ridden exercise" progressively decreased from week 3 (39.7%) to week 4 (36.9%), week 5 (31.9%), week 6 (28.0%), week 7 (21.6%), and week 8 (14.6%). Pasture turnout was rarely chosen on days 1–3 and ranged from 24.1% to 34.3% from day 4 until week 8. Aquatic exercise was included in 9.9–15.6% of the respondents' rehabilitation plans in weeks 2–8. During rehabilitation, 12.9% combined intra-articular polyacrylamide gel treatment with local physical modalities, such as laser or extracorporeal shockwave therapy, often commenting "when concurrent soft tissue injuries are present" or "on the surrounding soft tissues."

Clinical effects of polyacrylamide gel were mainly assessed 3–6 weeks after joint treatment (44.3%). In cases of reoccurrence of initial

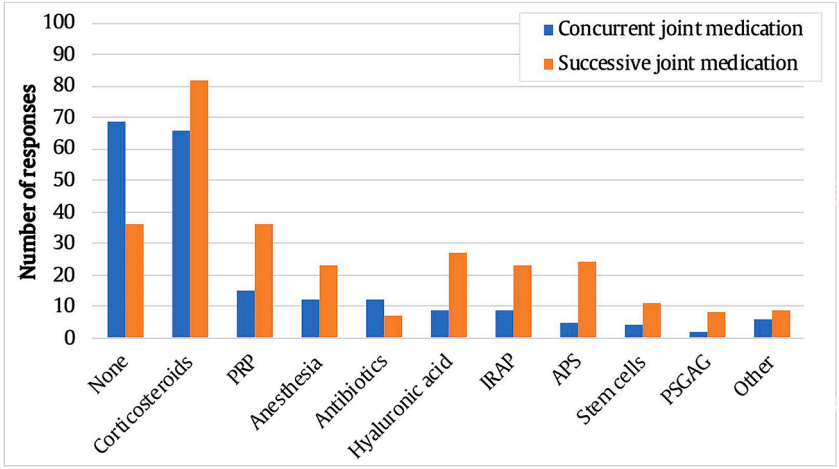

Fig. 2. Results of 140 respondents' answers to Questions 17 and 18 about combined intra-articular medication with polyacrylamide gel in horses. APS: autologous protein solution; IRAP: interleukin-1 receptor antagonist protein; PRP: platelet-rich plasma; PSGAG: polysulfated glycosaminoglycan.

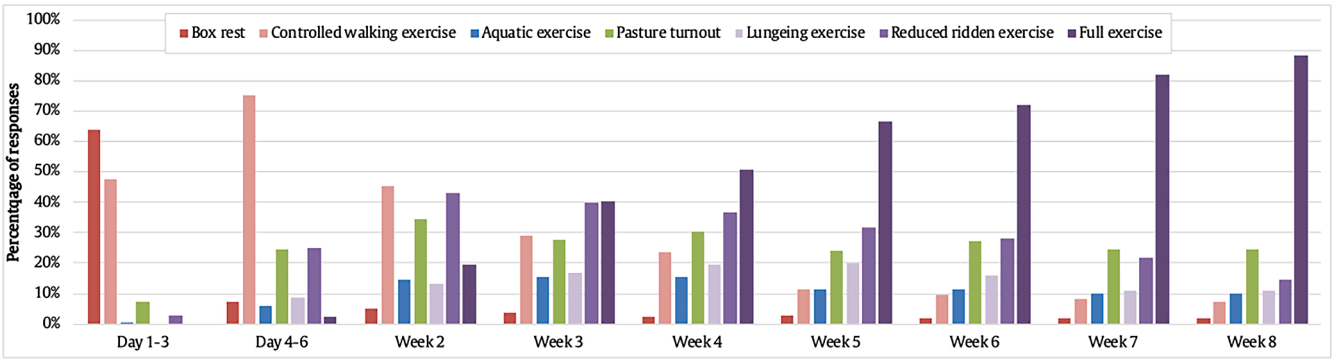

Fig. 3. Results of 139 respondents' answers to Question 20 about the rehabilitation plan in the first eight weeks post-treatment with intra-articular polyacrylamide gel in horses.

complaints, the respondents reported this occurred after 1–3 months (32.1%), 3–6 months (32.9%), and 6–12 months (27.1%).

3.2.6. *Outcomes, complications, and satisfaction*

The observed effects after polyacrylamide gel treatment are presented in Fig. 4. More than half of the respondents (51.8%) reported full recovery in more than 50% of their treated cases. Partial or transient improvement was observed mainly in 25–50% of the cases. Most respondents (74.3%) indicated no improvement in less than 25% of their cases. Worsening of joint function after intra-articular polyacrylamide gel treatment had never been observed by 42.1% of respondents, while 47.1% indicated worsening in less than 10% of the treated cases.

Most respondents have never noticed complications after polyacrylamide gel treatment (54.3%). For others, the main observed complications were joint flare (41.4%), joint effusion (13.6%), and joint infection (4.3%). Respondents mainly reported the frequency of occurrence of these complications as being lower than 1% (55.4%) or 1–5% (26.2%) of the cases. When a complication occurred, it affected mainly distal interphalangeal joints (56.3%) and fetlock joints (51.6%) and was not related to a specific polyacrylamide gel product.

The median overall satisfaction score for intra-articular polyacrylamide gel treatment was 8/10 (interquartile range: 6–9).

3.3. *Comparison between categories of respondents*

3.3.1. *Product used*

Of all respondents using Noltrex®Vet, 98.3% had experience using ArthramidVet®, and of all respondents using ArthramidVet®, 42.0% had experience using Noltrex®Vet as well.

Respondents with less than five years of experience were more likely to have used ArthramidVet® (10.1%) than Noltrex®Vet (1.7%; $p<0.05$), and respondents treating mainly Western Performance horses reported using more often Noltrex®Vet (28.8%) than ArthramidVet® (15.9%; $p<0.05$). There were no other significant differences in any of the question answers between respondents using Noltrex®Vet and respondents using ArthramidVet®.

3.3.2. *Treatment protocols*

Practitioners administering polyacrylamide gel as a single injection (sole treatment) were less satisfied (7/10) than respondents who repeated the therapy after a poor response (9/10; $p=0.03$).

Satisfaction among practitioners who did not combine intra-articular polyacrylamide gel with other intra-articular treatments (both concurrently and successively) was lower (7/10) than that of those combining intra-articular polyacrylamide gel with intra-articular anesthesia (9/10; $p=0.01$) or intra-articular corticosteroids (8/10; $p=0.03$).

3.3.3. *Experience of practitioners and country of practice*

Among practitioners with over 20 years of experience, significantly more respondents reported using intra-articular polyacrylamide gel in more than ten cases per month (19.6%) compared to those with 11–20 years of experience (3.9%; $p<0.05$). Veterinarians with over 20 years of experience were significantly more likely to combine intra-articular polyacrylamide gel treatment with systemic antibiotics (10.9%; $p<0.05$) and less likely to combine it with systemic NSAIDs (45.7%; $p<0.05$) than practitioners with 11–20 years of experience (none combined polyacrylamide gel with antibiotics and 66.7% combined it with systemic NSAIDs). In the post-treatment rehabilitation plans, significant differences were noted between the respondent group with over 20 years of experience and those with 11–20 years of experience. The latter group indicated recommending pasture turnout significantly more often in days 1–3 (10.5%) compared to the former group (1.6%; $p<0.05$), less controlled walking exercise in week 3 (9.5% versus 22.9%; $p<0.05$) and week 4 (7.5% versus 16.5%; $p<0.05$), and more often recommended full exercise in week 4 (37.3% versus 22.4%; $p<0.05$) and week 6 (38.5% versus 53.3%; $p<0.05$).

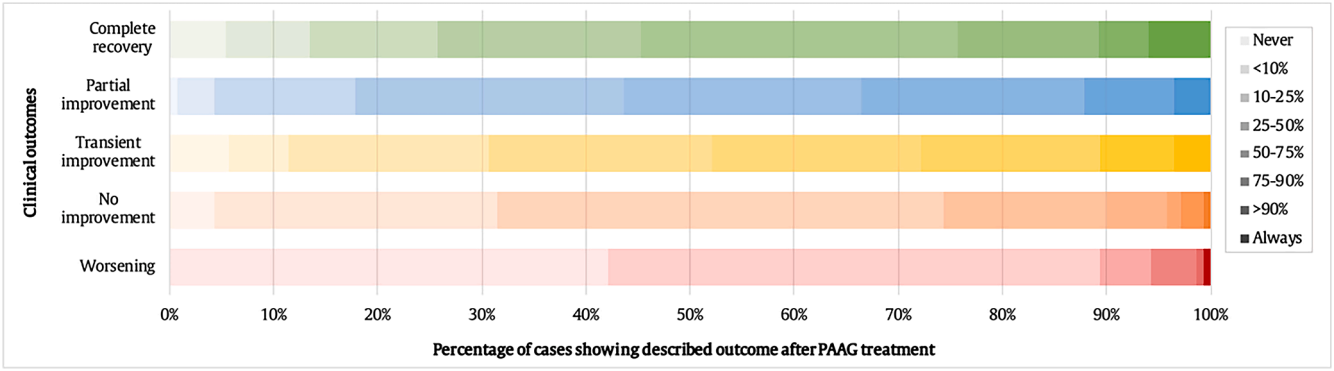

Fig. 4. Result of 140 respondents' answers to Questions 22–26 about the observed outcomes after intra-articular polyacrylamide gel (PAAG) treatment.

3.3.4. Horses' disciplines

Respondents focusing mainly on racehorses reported acute joint pain as a contraindication significantly more often (78.8%) than those working primarily with sports horses (53.5%; $p<0.05$). Respondents focusing mainly on leisure horses treated fewer horses with polyacrylamide gel, with 44.9% treating less than one horse per month, compared to only 18.2% of respondents working mainly with racehorses ($p<0.05$). Systemic PSGAG was significantly more often combined with intra-articular polyacrylamide gel treatment in the group primarily focusing on racehorses (39.4%) compared to those working mainly with sports horses (18.1%; $p<0.05$) or leisure horses (14.5%; $p<0.05$).

Hand-walking was significantly more frequently reported by respondents focusing on leisure horses compared to those focusing on racehorses, both on days 4–6 (60.0% versus 47.7%; $p<0.05$) and in week 3 (24.6% versus 12.7%; $p<0.05$) after polyacrylamide gel treatment. In week 2, respondents treating mainly racehorses opted significantly more often for reduced ridden exercise (32.3%) than those primarily treating leisure horses (20.6%; $p<0.05$). In week 3, a significantly higher percentage of respondents focusing on racehorses reported patients returned to full exercise (38.2%) compared to those focusing on sports horses (24.5%; $p<0.05$) or leisure horses (15.5%; $p<0.05$). In week 4, significantly more respondents focusing on sports horses reported horses returned to full exercise (27.6%) compared to those focusing on leisure horses (20.4%; $p<0.05$).

4. Discussion

4.1. Respondents

This survey gathered 197 responses from practitioners practicing in 16 different countries. One-hundred-sixty completed the questionnaire, providing sufficient information to describe trends and compare respondent groups. Most respondents were equine practitioners in Germany, the United States, and the Netherlands. Due to the distribution ways of the questionnaire, among which direct contact with peers, the countries where the authors practice (*i.e.*, Germany and the Netherlands) were likely overrepresented. Also, polyacrylamide gel is not legalized for use in horses in every country, therefore responses from these areas in the world are sparse. Practitioners with varying years of experience responded, with the majority primarily treating equine cases and over 50% of their caseload being orthopedic patients. This group of practitioners is more likely to have experience with the use of polyacrylamide gel (88% of the respondents have experience using polyacrylamide gel) and more likely to be interested in participating in this survey compared to practitioners focusing on areas other than equine orthopedics. In a survey on the use of non-steroidal intra-articular treatment in horses, Alverez et al. (2020) [19] also described that practitioners were more likely to use non-steroidals if their caseload included predominantly equine patients. Furthermore, practitioners outside the USA more frequently used polyacrylamide gel than practitioners in the USA [19]. Contrarily, in the present study, respondents from the USA all had experience using polyacrylamide gel, and these products were available to all respondents practicing in the USA. This could be due to the approval in 2020 by the U.S. Food and Drug Administration (FDA) of ArthramidVet® for use in horses, which likely explains the increased availability and use of polyacrylamide gel in the USA.

4.2. Frequency of use of polyacrylamide gel

Over half of the respondents reported using intra-articular polyacrylamide gel less than once per month or only once or twice per month, while only one-tenth of the respondents used it in more than ten cases per month. Compared to the total number of joint treatments, practitioners reported opting for polyacrylamide gel in only 5% of their joint therapies. This showcases the relatively infrequent use of this product. A possible explanation might be the higher costs of this product compared to other joint treatment options, however the reasoning of practitioners whether or not to use polyacrylamide gel more frequently was beyond the scope of this survey. Corticosteroids, with or without hyaluronic acid, are the most commonly used drugs for intra-articular treatment of noninfectious arthritis [20,21]. In a recent survey on the use of non-steroidal intra-articular therapeutics by equine practitioners, the combination of corticosteroids and hyaluronic acid treatment remained the first choice among practitioners, followed by autologous conditioned serum, platelet-rich plasma, and autologous conditioned protein [20]. In this study, polyacrylamide gel was the least used product for joint treatment.

4.3. Indications and contraindications

The main indications for intra-articular polyacrylamide gel were chronic synovitis/osteoarthritis and failure of prior joint treatment. These indications were also most commonly chosen by respondents when polyacrylamide treatment was indicated over other intra-articular therapies. This suggests that practitioners often opt for different joint treatment options before using polyacrylamide gel, and therefore, polyacrylamide gel is primarily reported as treatment in chronic or recurrent cases. In the study of Alvarez et al. (2020) [20], the most common reason for using polyacrylamide gel was the treatment of chronic articular disorders and severe osteoarthritis unresponsive to other therapies, which is consistent with the findings in the present survey. Furthermore, clinical studies on the use of polyacrylamide gel in horses have predominantly focused on treating chronic osteoarthritis [11,13,14], or in joints that showed poor responses to prior joint treatments [14,15].

Acute joint pain and preventative joint treatment were the most commonly reported contraindications. Since polyacrylamide gel sets into the synovial membrane and is non-degradable and non-absorbable [3,6], it could impair the removal of bacterial infection treatment in a (suspected) septic joint. Some respondents mentioned "(suspected) septic joint infection" as other contraindications. A 2.5% polyacrylamide gel treatment has been indicated for osteoarthritis from the early to chronic stage [15]. It has been described as a safe and effective modality for use in acute joint disease in horses [1,7,15]. Practitioners treating mainly racehorses more often selected acute joint pain as a contraindication than those treating primarily horses in other disciplines. The present study does not clarify the reasoning behind not treating joints with polyacrylamide gel after an acute onset of joint pain. Acute joint pain is a clinical sign rather than a diagnosis, and can result from either an acute inflammatory process, such as acute synovitis or arthritis, or from trauma. In racehorses, underlying bone disorders, such as fissure fractures, are more prevalent than in horses from other disciplines [22], making it more likely for practitioners mainly treating racehorses to avoid any intra-articular treatment modality in cases of acute joint pain caused by underlying bone disease.

4.4. Observed improvement after treatment

More than half of the respondents reported full recovery in more than 50% of their treated cases. Multiple clinical studies on the use of a 2.5% polyacrylamide gel describe horses as free of lameness in 53–83% of treated cases at timepoints ranging from 1–24 months post-injection [11–16]. A study on a 4.0% polyacrylamide gel described a decrease in lameness in 82% of horses with naturally occurring osteoarthritis [18]. Since the main indication for using intra-articular polyacrylamide gel among respondents in the present survey was chronic synovitis/osteoarthritis, therapy outcomes for this condition should be considered. In chronic osteoarthritis, the goal of joint treatment in general is often to alleviate clinical signs rather than completely restore joint function and clinical soundness. Therefore, partial or transient improvement is sometimes the highest achievable outcome after any treatment for

chronic joint pain. In this survey, most respondents observed partial or transient improvement in a high percentage of horses. "No improvement after intra-articular polyacrylamide gel injection" was reported in less than 25% of their cases.

4.5. Product used

Most polyacrylamide gel users in this survey have used ArthramidVet® (98.6%), and Noltrex®Vet (42.1%). There are recognized differences between these polyacrylamide gels used for intra-articular treatment in the horse [9]. The initial differences in polyacrylamide content (2.5% and 4.0%) indicate a difference of 1.5% in concentration, but they are also likely to differ in physical structure [9]. The mechanism of action of the 4.0% polyacrylamide gel is surface and boundary lubrication [8], while 2.5% polyacrylamide gel has been shown to integrate into the synovial membrane and remains there for an extended period of time [1,3,4,7]. Based on these differences, it was hypothesized that using different polyacrylamide gel products (*e.g.*, ArthramidVet® and Noltrex®Vet) could have led to variations in outcome, complications, and satisfaction between respondents in this survey. Using an automated A/B test, significant differences were found in responses to the questions regarding demography (*i.e.*, years of experience and main disciplinary focus; $p<0.05$),. However, no significant differences were observed in responses to any other questions between users of Noltrex®Vet and ArthramidVet®, possibly because the majority of respondents had used both products.

4.5. Safety

Polyacrylamide gel has demonstrated a favorable safety profile in humans, with minimal inflammatory reactions or adverse effects reported [23,19]. In horses as well, polyacrylamide gel has been described as a highly safe product for intra-articular treatment [1,6,15], with a reported complication rate of 0.004% after joint injection with 2.5% polyacrylamide gel [1]. In the present survey, most respondents indicated never noticing complications after intra-articular polyacrylamide gel treatment. Respondents who experienced complications mainly reported an incidence of less than 1%. Distal interphalangeal joints and fetlock joints were most often selected as joints with complications. However, these joints are also the most commonly treated in this survey. Therefore, it cannot be concluded that these joints have a higher risk of complications. The most frequently selected complications were joint flare and joint effusion. It has been described that periarticular polyacrylamide gel administration of a 4.0% polyacrylamide gel containing silver ions can result in swelling and effusion, as it is hydrophilic [17]. The frequency of occurrence of a joint flare was also questioned in the survey by Alvarez et al. (2020) [20], where 37% reported an acute joint flare after treatment with polyacrylamide gel (whether a 2.5% or 4.0% polyacrylamide gel was used is not specified in this study). The occurrence of an acute joint flare after different non-steroidal joint treatments was slightly more common, where 55% of respondents reporting an acute joint flare after the use of platelet-rich plasma, 49% after autologous conditioned serum, 40% after autologous protein solution, and 54% after cellular joint therapies [20]. This showcases the relatively low incidence of joint flare after intra-articular polyacrylamide gel treatment compared to other non-steroidal products, aligning with the findings in the present survey.

4.6. Treatment protocols: joints, volumes, and frequency

Respondents treated various joints with polyacrylamide gel, with the most common being fetlock joints, distal interphalangeal joints, stifle joints, proximal interphalangeal joints, carpal joints, and tarsal joints. Clinical studies on polyacrylamide gel treatment have described its effects in fetlock joints [14], carpal joints [11,12,14], distal interphalangeal joints [13,15], and proximal interphalangeal joints [15]. These joints are the most commonly affected by osteoarthritis in the horse [24]. Smaller volumes were used for smaller joints, and larger volumes for larger joints. However, no more than 4 ml was injected. Tnibar et al. (2022) described the recommended volumes of polyacrylamide gel for use in different joints [1]. Respondents in the present survey mainly opted for volumes similar to these recommendations.

Among respondents, polyacrylamide gel is mainly used as a single injection, while repeated injections after a poor response to the initial polyacrylamide gel treatment were less common. However, practitioners who opted for a second injection after a poor response to the first polyacrylamide gel treatment were generally more satisfied than respondents using polyacrylamide gel as a single treatment. The treatment protocol in the present survey resembled the findings from Alvarez et al. (2020) [20], where a one-time injection was most common (45%), and repeated injections based on short-term clinical responses were performed by 16% of the respondents. In other studies, repeating polyacrylamide gel treatment after poor or partial improvement following initial treatment has been recommended [1,18].

4.7. Combined intra-articular corticosteroid therapy

Many respondents never combined the polyacrylamide gel treatment with other intra-articular medication, both concurrently or successively. This suggests that polyacrylamide gel is more often used after prior joint treatment than as a combination therapy at the same time. However, the effect and safety of combining polyacrylamide gel with other intra-articular medications have not yet been described. There was no difference in clinical outcome (*i.e.*, improvement or worsening) or complication rate between respondents who did or did not combine polyacrylamide gel with other intra-articular medications.

Administration of corticosteroids (concurrently or successively) was common, with a higher overall satisfaction score than sole polyacrylamide gel therapy. The effects of corticosteroids on joint pathology have been widely studied [21,25,26]. Possibly, combining the mechanisms of corticosteroids (anti-inflammatory effect) and polyacrylamide gel (mechanical effect through integration into the synovial membrane, increase in joint elasticity, and protection of articular surfaces [1,3,4]) could result in a higher and more durable effect on reducing lameness, potentially leading to higher satisfaction among practitioners. Recently, a study assessed the safety and tolerability of concurrent intra-articular 2.5% polyacrylamide gel and betamethasone acetate esters, and concluded this to be safe and well tolerated in the metacarpophalangeal joints of ten healthy riding horses [27]. No in-depth information on the reasoning for opting for polyacrylamide gel treatment combined with intra-articular corticosteroids or other medications was obtained in the present study. The rationale for using both medications simultaneously or at different times could be an expected enhanced effect on joint pain, as described above. However, many practitioners in the present survey indicated using polyacrylamide gel treatment after prior failed joint treatment. It is possible that polyacrylamide gel was chosen successively to corticosteroids not to enhance treatment effect but as a second-choice treatment option after the failure of corticosteroid treatment. Practitioners' satisfaction cannot directly be related to patient outcomes; however, it is likely higher after favorable treatment outcomes. Satisfaction with the use of polyacrylamide gel is possibly higher because of positive treatment outcomes, either through the combined effect of the medications or through the positive effect of polyacrylamide gel after a poor treatment outcome following prior corticosteroid treatment.

4.8. Combined intra-articular anesthesia

Respondents who combined polyacrylamide gel with intra-articular anesthesia were more satisfied (9/10) than those who did not combine polyacrylamide gel with other intra-articular medications (7/10). Different studies on the use of polyacrylamide gel pointed out the importance of abolishing lameness by intra-articular anesthesia before

using a 2.5% polyacrylamide gel [1,7,11–16]. The reasoning for respondents in the present survey to combine intra-articular anesthesia, either successively or concurrently, was not determined. Blocking the joint could have been performed as a diagnostic tool to assess the effect of the joint anesthesia on lameness, thereby helping to decide on the usefulness of polyacrylamide gel as a therapeutic option. Another explanation could be that combining polyacrylamide gel with a local anesthetic concurrently may reduce post-injection pain. Due to the higher viscosity of the product, pressure on the joint capsule can cause post-injection pain and lameness [17], potentially influencing overall satisfaction with polyacrylamide gel. This side effect could be alleviated by using an intra-articular anesthetic.

For successful therapy outcomes, it is essential to inject the polyacrylamide gel into the articular space [1,7,15]. Due to the high viscosity of the product, the sensation of injecting it into the articular cavity differs from that of more soluble agents (*e.g.*, corticosteroids). Soluble substances can be injected smoothly into the articular cavity [24], where injecting polyacrylamide gel creates more resistance. Therefore, distinguishing between intra-articular or peri-articular injection of polyacrylamide gel can be more challenging. Injecting into the synovial membrane instead of into the joint space will create a bulging of the synovial membrane and the gel will not diffuse correctly into the joint space [1]. Injecting a soluble substance (*e.g.*, an anesthetic solution) through the same needle prior to polyacrylamide gel may help prevent the incorrect peri-articular or intra-synovial injection of polyacrylamide gel.

4.9. Combined systemic treatment

Systemic NSAIDs and bisphosphonates were frequently selected as combined therapies combined with intra-articular polyacrylamide gel treatment. However, a fourth of the respondents never combined polyacrylamide gel with systemic treatment. While NSAIDs selectively inhibit the pathway of cyclo-oxygenase-2 iso-enzyme, the result is impaired production of prostaglandins. Oral NSAIDs have been used to relieve pain and inflammation in various species, including horses, for disorders like osteoarthritis [25]. Therefore, NSAIDs are often combined with intra-articular joint treatments. Practitioners with 11–20 years of experience more often combined intra-articular polyacrylamide gel treatment with NSAIDs than those with over 20 years of experience, who more often used systemic antibiotics. Tnibar (2024) [1] recommended to avoid intra-articular injection of antibiotics with polyacrylamide gel. If the clinician wishes to inject antibiotics simultaneously with polyacrylamide gel, one prophylactic systemic administration of antibiotics before injecting polyacrylamide gel is recommended. However, prophylactic use of antibiotics has been increasingly questioned due to concerns about antibiotic resistance [28–30]. Therefore, practitioners who graduated more recently might be more cautious about using prophylactic antibiotics for an intra-articular polyacrylamide gel treatment, which is considered safe [1,6,15].

Bisphosphonates inhibit osteoclast activity and have a pain-relieving effect on bone pain in horses [31]. While bisphosphonates are approved in horses primarily for treating navicular syndrome, they are also used in various bone-related disorders due to their pain-modulating effect and ability to reduce lameness [31–33]. Tiludronate has been shown to inhibit the radiographic progression of osteoarthritis by reducing subchondral bone remodeling [32]. Therefore, this drug is often used in painful joint conditions, such as chronic osteoarthritis. The high percentage of respondents indicating polyacrylamide gel treatment for chronic joint pain could explain the relatively high rate of respondents using systemic bisphosphonates in these cases. However, the present survey cannot conclude whether combining intra-articular polyacrylamide gel treatment with systemic bisphosphonates results in a favorable outcome.

4.10. Post-treatment rehabilitation

Post-treatment rehabilitation plans varied between respondents. A trend was observed starting from box rest in the first three days, followed by increased activity with controlled hand-walking on the next three days until the second week. In week 3, most respondents reported prescribing either reduced ridden exercise or full exercise. From week 4 onward, most respondents chose full exercise. Tnibar (2024) advised a week of box rest and hand-walking for most cases treated with 2.5% polyacrylamide gel, after which horses can progressively resume their regular activity [1]. In the study of McClure et al. (2017), racehorses treated for carpal joint lameness were rested for 2–3 days, followed by walking exercise for a week, and then low-impact exercise with a gradual return to full exercise over 2–3 weeks [18].

Pasture turnout was rarely included in the rehabilitation protocol for the first three days, but about a third of the respondents included it from day 4. Low-impact exercise is recommended for horses with osteoarthritis [34], and pasture turnout could be considered a low-impact exercise. However, exercise in the pasture cannot be controlled due to the horse's natural flight instinct [35]. Therefore, the temperament of the individual horse might play a role in whether pasture turnout is included in the post-treatment rehabilitation plan.

Aquatic exercise may be beneficial in rehabilitating lower limb injuries, such as osteoarthritis, since water immersion during treadmill exercise has been shown to reduce segmental accelerations and increase attenuation in horses [36]. In the present survey, aquatic exercise was reported by 10–15% of the respondents to be included in weeks 2–8 of rehabilitation. The survey did not assess the decision to incorporate aquatic exercise post-treatment. Still, it can be assumed that factors such as availability, costs, patient behavior, and the respondent's personal experience could play a role.

Differences in post-treatment rehabilitation plans were observed depending on the practitioner's experience and primary focus. On average, racehorse practitioners and those with over 20 years of experience recommended shorter periods of box rest and controlled walking, and started exercise under saddle sooner than practitioners focusing on sports horses and leisure horses and respondents with 11–20 years of experience. Whether this trend is also observed with other intra-articular medications is unclear, as the present survey focused solely on using polyacrylamide gel. Differences in the horses' discipline likely explain these variations in rehabilitation plans. In racing, performance careers are generally shorter than in sports horses, and days out of racing can have significant financial impacts. As a result, practitioners focusing on racehorses may opt for shorter rehabilitation protocols after polyacrylamide gel treatment compared to those focusing on other disciplines.

Post-treatment rehabilitation protocols do likely differ depending on the indication of polyacrylamide gel treatment, but this survey did not supply in-depth information on individual rehabilitation plans. Currently, there are no scientific guidelines on the effect of rehabilitation protocols following polyacrylamide gel treatment or any other intra-articular medications. Protocols are mainly based on empirical and anecdotal experiences rather than scientific research; therefore, differences may arise depending on the years of experience. Further research into the treatment outcomes of various post-treatment rehabilitation plans is needed to establish evidence-based guidelines for optimal rehabilitation strategies after intra-articular polyacrylamide gel treatment.

4.11. Post-treatment follow-up

Most respondents assessed the effect of polyacrylamide gel treatment between 3–6 weeks post-treatment and reported reoccurrence of initial complaints after 1–3 months (32.1%), 3–6 months (32.9%), and 6–12 months (27.1%). Lowe et al. (2024) described that the product is fully integrated into the synovial membrane after two weeks [6]. A full

response to treatment typically begins one week post-injection, but it may take several weeks, or, in rare cases, a few months [1]. Clinical studies assessing initial therapy outcomes primarily evaluated patients after 1 month [11–15,17], with follow-up periods ranging from 3 months [12,14], 6 months [12–14], 12 months [15], or up to 24 months [14,15]. The response to therapy with intra-articular 4.0% polyacrylamide gel typically occurs predominantly in the first three weeks and is sustained up to 90 days in 75% of horses [17]. Therefore, initial follow-up between three and six weeks after treatment seems appropriate, and additional follow-ups are recommended in cases of poor or partial beneficial responses to intra-articular polyacrylamide gel treatment.

4.12. Limitations

As survey limitations, answers to questions regarding clinical response and complication rates were based on subjective estimation and practitioners' recall rather than clinical records, so no in-depth information was gathered. This survey did not focus on the use of one specific polyacrylamide gel product, since different products might be registered and/or used by respondents from different countries in this international survey. As a consequence, outcome of each specific polyacrylamide gel product could be compared but not be analyzed separately, since most respondents have used both ArthramidVet® and Noltrex®Vet. There is also potential selection and response bias, as most respondents are specialized in or focused on equine orthopedics. Lastly, the survey format primarily allowed responses designed by the developers and offered limited opportunities to supply additional information. Additionally, the survey was developed by equine sports medicine specialists and, as such, may have been phrased in a way that could imply certain answers.

5. Conclusion

To the authors' knowledge, this is the first survey assessing the indications, treatment protocols, rehabilitation plans, outcomes, and general satisfaction with intra-articular polyacrylamide gel among practitioners. The main indications for using polyacrylamide gel are chronic synovitis/osteoarthritis or treatment following prior unsuccessful joint therapies. Treatment protocols and rehabilitation plans varied between practitioners and respondent groups, depending on years of experience and disciplinary focus. Complications, worsening, or lack of improvement after treatment were uncommonly reported, with complete recovery, partial improvement, or transient improvement more often observed as outcomes. The median overall satisfaction for intra-articular polyacrylamide gel therapy was 8 out of 10, which shows that most respondents were highly satisfied with using polyacrylamide gel products for intra-articular treatment in horses. This survey reports practitioners' experience with polyacrylamide gel and outlined their treatment and rehabilitation strategies. Further studies are necessary to develop guidelines for optimal intra-articular polyacrylamide gel treatment and post-treatment rehabilitation protocols in horses.

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Mathilde Pluim: Writing – original draft, Visualization, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Thibault Frippiat:** Writing – review & editing, Visualization, Methodology, Investigation, Formal analysis.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jevs.2025.105610.

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