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Perceptions of Minimally Invasive Osteosynthesis: A 2018 Survey of Orthopedic Surgeons

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21 **Abstract**

22 **Objective:** To report perspectives of minimally invasive osteosynthesis techniques in
23 veterinary surgical practice in 2018

24 **Study design:** Electronic questionnaires

25 **Sample population:** Diplomates and residents of the American & European Colleges of
26 Veterinary Surgery (ACVS & ECVS) and members of the Veterinary Orthopedic Society
27 (VOS)

28 **Methods:** Survey questions pertaining to minimally invasive osteosynthesis (MIO) and
29 minimally invasive plate osteosynthesis (MIPO) were sent electronically to the sample
30 population. Questions assessed training, current caseload, benefits and limitations of MIO
31 and MIPO.

32 **Results:** Two hundred and fifty-six veterinary surgeons completed questions pertaining to
33 MIO and 238 veterinary surgeons completed questions pertaining to MIPO. When
34 considering MIO, only 16% of respondents reported that they performed MIO techniques
35 regularly or exclusively and 62% wanted to perform more MIO than they were currently
36 undertaking. Tibial fractures were most commonly selected for MIO/MIPO stabilization
37 techniques in both cats and dogs. Challenges in achieving adequate fracture reduction was
38 identified as the biggest limitation of MIO/MIPO techniques. Forty three percent of
39 respondents felt there weren't enough MIPO training opportunities.

40 **Conclusions:** Currently MIO/MIPO techniques are performed infrequently with a large
41 proportion of respondents revealing that they would like to perform more in the future. There
42 is also evidence that further training opportunities would be welcomed when considering
43 MIPO.

44 **Clinical significance:** Despite evidence of the benefits of MIO and MIPO over more
45 traditional fracture stabilization approaches our survey has highlighted that significant
46 barriers remain before the techniques are likely to be more widely adopted.

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64 **Introduction:**

65 In recent years there has been a trend in both human and veterinary medicine away from
66 anatomical reconstruction and rigid internal fixation towards more biological approaches to
67 fracture fixation.¹⁻³ Minimally invasive osteosynthesis (MIO) techniques, are becoming
68 widely accepted as alternatives to open reduction and internal fixation (ORIF) for the
69 stabilization of fractures. By definition MIO includes any fracture fixation technique that
70 involves small skin incisions and avoidance of the deeper surgical/ fracture site. An
71 intermediate surgical approach known as an ‘open but do not touch’ (OBDNT) can be
72 utilized which lies somewhere between MIO and ORIF.^{3,4} The authors are not aware of any
73 study focusing on the benefits/ limitations of an OBDNT approach over other methods.
74 Numerous MIO techniques are reported in the veterinary literature for the treatment of long
75 bone fractures including external skeletal fixation,⁵⁻⁸ minimally invasive plate osteosynthesis
76 (MIPO)⁹⁻²⁰ and interlocking nails.^{4,21-24} MIO techniques have also been applied to articular
77 fractures,²⁵ sacroiliac joint luxation stabilization^{26,27} and central tarsal bone luxation
78 stabilization.²⁸ Reported advantages of MIO/MIPO techniques in human and veterinary
79 patients include reduced postoperative pain,²⁹ preservation of the fracture hematoma,^{1,30}
80 improved vascularization of the fracture site,³¹⁻³³ more rapid healing,^{4,11,15,17,29,34,35} less wound
81 complications^{12,17,36} and faster return to normal function compared with open approaches.^{29,36}
82 Disadvantages reported include the technical difficulty of the learning process, longer
83 operating times,³⁷ prolonged healing,³⁸ fracture malreduction³⁴ and radiation safety issues
84 associated with intraoperative fluoroscopy.^{37,39} With the conflicting evidence Kulkarni et al³⁶
85 advocated an individual approach to each fracture based on a cost/ benefit analysis.
86
87 Minimally invasive plate osteosynthesis was first described by Brunner and Weber in the
88 early eighties.⁴⁰ It involves the closed and indirect reduction of fractures followed by the

89 application of a bone plate without making an extensive surgical approach to the fracture site.
90 Typically, small skin incisions are created at either end of the fractured long bone. A plate is
91 then inserted through one of the incisions and passed through an epiperiosteal tunnel which
92 spans the fracture site. Screws are then applied in the proximal and distal ends of the plate.¹⁸
93 Advancements in implant technologies, in particular the introduction of locking plates,
94 increased availability of intraoperative imaging and evolution of indirect fracture reduction
95 techniques has resulted in MIPO gaining popularity in human orthopedic surgery.

96

97 Despite the presence of multiple studies advocating and reporting the use of MIO and MIPO
98 techniques in both the veterinary and human literature there still remains conflicting evidence
99 about the direct benefits of these approaches over more traditional rigid internal fixation
100 techniques.^{11,15,19,37,41} The veterinary literature to date has focused on objective benefits but
101 has not identified whether these techniques are widely performed by the veterinary
102 orthopedic community. A recent study demonstrated that minimally invasive surgical
103 techniques were widely used by American College of Veterinary Surgeons (ACVS)
104 Diplomates and residents but this study did not specifically investigate the application of
105 MIO/MIPO techniques.⁴² There is a paucity of data with regards to current application,
106 training opportunities, perceived benefits and limitations of MIO/MIPO and motivating
107 factors for performing these techniques. The objective of our study was to assess the current
108 perceptions and applications of MIO/MIPO techniques amongst a population of veterinary
109 orthopedic surgeons.

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113 **Materials & Methods:**

114 Two electronic surveys were created using an Online Survey tool
115 (www.onlinesurveys.co.uk). Ethical approval for the study was granted by the Ethical
116 committee at the University of Bristol (Application 60043).

117

118 A link to the initial survey was provided by electronic mail to all small animal European
119 College of Veterinary Surgery (ECVS) Diplomates and residents containing questions
120 pertaining to minimally invasive osteosynthesis (MIO). This was then followed by another
121 link to a second survey pertaining to MIPO which was also sent by electronic mail to all
122 small animal ECVS Diplomates and residents. Finally, a link to the amalgamated survey
123 (consisting of questions from the first and second survey) was circulated to members of the
124 Veterinary Orthopedic Society (VOS) via electronic mail and posted on the American
125 College of Veterinary Surgery (ACVS) small animal surgical forum.

126

127 Survey feedback and assistance was provided on an individual basis by email
128 correspondence. Responses were only included if the questions were complete and returned
129 within a 14-week period between February & May 2018. A survey response percentage was
130 calculated where possible for the individual populations. The amalgamated survey sent to the
131 VOS and ACVS can be found in the supplementary information online (Appendix 1).

132

133 *Statistical analysis:*

134 Descriptive statistical analysis was performed and presented as both counts and percentages
135 of survey respondents. Groups were broadly defined based on age (over or under 50 years of

136 age) and Diplomate status (Diplomates vs non-Diplomates). Chi-squared tests were used to
137 evaluate if there were any relationships between the age or Diplomate status of the
138 respondents and relevant respondent's answers. An alpha of ≤ 0.05 was used for tests.

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156 **Results:**

157 *Survey response*

158 In total 171 surgeons responded to the first survey, 153 responded to the second survey and
159 85 responded to the amalgamated survey. Both the first and second survey were sent to the
160 619 small animal members of the ECVS which equates to a 27.6% and 24.7% response rate,
161 respectively. The total number of people exposed to the survey when it was circulated to the
162 ACVS online forum and VOS is unknown and so response rates could not be calculated for
163 these populations.

164

165 *Minimally invasive osteosynthesis*

166 Of the 256 veterinary surgeons who completed the questions pertaining to minimally invasive
167 osteosynthesis, 73% were male (n=187) and 27% female (n=61). Seventy three percent
168 (n=187) of respondents were 31-50 years of age. The Diplomate status for this group of
169 respondents is presented separately (Figure 1). The majority of respondents (97%, n=248)
170 reported that fractures consisted between 0-50% of their surgical caseload. Forty-one
171 respondents (16%) stated that they performed MIO procedures regularly or exclusively. One
172 hundred and fifty-seven respondents (62%) reported that they wanted to perform more MIO
173 techniques than they currently did.

174

175 The three most common canine fractures addressed by the respondents using MIO techniques
176 were tibial diaphyseal (82%, n=211), radial diaphyseal (45%, n=116) & femoral diaphyseal
177 (45%, n=91) fractures.

178

179 The most frequent perceived advantages identified for MIO were faster healing time (64%,
180 n=164), less post-operative pain (48%, n=123) and faster return to function (44%, n=113).
181 The most commonly reported perceived limitations of MIO techniques were challenges to
182 obtaining adequate fracture reduction (62%, n=158), technical difficulty (47%, n=120),
183 increased surgical time (38%, n=97) and radiation safety issues (36%, n=92). When asked
184 which of these was the most significant perceived limitation challenges to obtaining fracture
185 reduction and the requirement for new equipment (Figure 2) were the two most frequently
186 chosen options.

187

188 *Minimally invasive plate osteosynthesis*

189 Two hundred and thirty-eight veterinary surgeons completed questions pertaining to MIPO.
190 Seventy four percent were male (n=177) and 26% were female (n=61). Seventy two percent
191 (n=171) of respondents were between 31 & 50 years of age. Fifty nine percent (n=140) of
192 respondents worked in private referral practice and 31% (n=73) in academic centers. Seventy
193 one percent of respondents (n=169) performed MIPO for fracture fixation rarely or
194 occasionally. Eighteen percent of respondents (n=42) reported that they have never
195 performed MIPO before. Sixty three percent of respondents (n=151) wanted to apply MIPO
196 more frequently than they were at the current time. Fractures most commonly stabilized with
197 MIPO in dogs were tibial fractures (77%, n=184) followed by radial fractures (47%, n=112).
198 Fractures most commonly stabilized with MIPO in cats where tibial fractures (55%, n=133)
199 followed by femoral fractures (24%, n=57). A higher proportion of respondents had never
200 performed MIPO in cats compared with dogs (39% vs 15% respectively).

201

202 Respondents were asked to consider what surgical method they would elect to perform when
203 stabilizing a non reconstructible, comminuted, mid diaphyseal fracture of the tibia, humerus,
204 femur and radius in a 20 kg dog and 5 kg cat. The responses for preferred stabilization
205 method for each scenario are shown separately (Figures 3 and 4). When considering MIPO
206 training 40% (n=95) of respondents stated that they had taught themselves MIPO techniques
207 and 40% (n=95) reported that they had received specific MIPO training during their
208 residency. Forty three percent (n=104) of surgeons felt that there were not enough training
209 opportunities available for MIPO techniques. Forty two percent (n=101) of respondents
210 indicated that they had never used fluoroscopy when performing MIPO.

211

212 The four most common perceived limitations to performing MIPO were challenges to
213 obtaining fracture reduction (25%, n=60), requirement for new equipment (16% n=38), lack
214 of training opportunity (14% n=33) and lack of proven benefit and/or efficacy (12%, n=28).

215

216 *Statistical analysis*

217 An association ($\chi^2 = 9.573$, $df = 3$, $p = 0.02$) was found between Diplomate status and the
218 response to how much MIO the respondent would like to perform when compared with their
219 current level (Table 1), with non-Diplomates being more likely to want to perform more MIO
220 techniques than their current level.

221

222 A similar relationship was found between Diplomate status and responses to the questions
223 regarding how much MIPO the respondent would like to perform when compared with their
224 current level ($\chi^2 = 16.255$, $df = 3$, $p \leq 0.001$) and whether they felt there were enough training

225 opportunities for MIPO ($\chi^2 = 19.157$, $df = 3$, $p \leq 0.001$) (Tables 2 & 3). Non-Diplomates
226 were more likely to want to perform more MIPO than they currently did and they were more
227 likely to report that there are inadequate MIPO training opportunities.

228

229 Relationships were found between age of the respondent and responses to the questions
230 regarding how much MIPO the respondent would like to perform when compared to their
231 current level ($\chi^2 = 9.205$, $df = 3$, $p = 0.023$) and whether they felt there were enough training
232 opportunities for MIPO ($\chi^2 = 9.065$, $df = 3$, $p = 0.032$) (Table 4 and 5). Younger respondents
233 were more likely to want to perform more MIPO than they currently did and stated that there
234 are not enough MIPO training opportunities.

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246 **Discussion:**

247 To the best of the authors' knowledge this is the first survey assessing the current
248 perspectives of MIO and MIPO in the veterinary literature. A large proportion of respondents
249 (62%) highlighted that they wanted to perform more MIO and MIPO techniques than they
250 were currently doing. This suggests that a considerable proportion of respondents perceive
251 significant benefits of MIO and MIPO over more traditional approaches but for undisclosed
252 reasons were not currently performing these methods. The survey has however identified that
253 there are barriers to performing MIO and MIPO in veterinary orthopedic practice. This
254 appears to be in contrast to other minimally invasive surgeries such as laparoscopy or
255 thoracoscopy which were reported to be more commonly performed than the MIO/MIPO
256 techniques in our study.⁴²

257

258 Results of the survey demonstrate that within the population of respondents MIPO was not
259 being performed as commonly in feline patients when compared with dogs. The reason for
260 this difference is currently unknown as respondents were not specifically asked to comment.
261 Potential explanations would include a relatively lowercase load for feline fractures in
262 practice, or the smaller patient size which may be associated with a greater number of
263 technical difficulties when performing MIPO in these patients.

264

265 In both cats and dogs, tibial fractures were reported to be the most commonly chosen long-
266 bone fracture to be stabilized with a MIPO approach. This is likely to be associated with the
267 relative ease of reduction of fractures of the tibia and the absence of significant soft tissue
268 when compared with other bones, but this was not specifically investigated in the survey.

269 When asked how respondents would approach non-reconstructible, comminuted, mid

270 diaphyseal fractures in different bones in a 20kg dog and a 5kg cat, the most frequently
271 chosen answer was an ‘open but do not touch approach with a plate and intramedullary (IM)
272 pin’, with the exception of the radius where an IM pin cannot be safely placed without
273 damaging the joints either side of the fracture. This suggests that many respondents recognize
274 the benefits of a more biological approach to fracture stabilization, including minimising
275 surgical trauma and preservation of the fracture haematoma over more traditional open
276 approaches. That said, in the authors experience, there is a very wide margin of interpretation
277 of exactly what pertains to an open but do not touch approach ³ and limited objectivity of this
278 technique in the literature. Further studies are required to investigate if there are any
279 significant differences between fracture healing and outcome when comparing an ‘open but
280 do not approach’ and MIPO.

281

282 Non-Diplomates were more likely to want to perform more MIPO and MIO when compared
283 with their current level. This may reflect that MIO and specifically MIPO techniques are
284 challenging and require a steeper learning curve which may be perceived to be too complex
285 by inexperienced surgeons at the start of their career. Younger respondents were also more
286 likely to want to perform more MIPO than their current level which again may support the
287 theory that MIPO techniques are more technically challenging than open approaches, but the
288 benefits are acknowledged. These differences may also be explained by the fact that there is
289 more evidence supporting MIPO and MIO approaches in the recent literature which may
290 encourage respondents who are currently training to perceive the benefits but due to the steep
291 learning curve are reluctant to perform MIPO procedures.

292

293 Our study highlights that the most significant perceived limitations when performing MIPO
294 were challenges when attempting fracture reduction, requirement for new equipment and a
295 lack of proven benefit/ efficacy. The perceived limitations of MIO were similar to those for
296 MIPO with challenges when attempting fracture reduction being the most commonly cited.
297 Numerous techniques have been described to aid with fracture reduction including basic
298 external skeletal fixators, distraction devices, plate fixation itself and other instruments such
299 pointed reduction forceps.^{11,14,43,44} A novel approach has recently been reported with the use
300 of a 3D printed patient specific guide for repair of a comminuted humeral fracture in a cat¹³
301 which is an area with considerable potential for use in these cases. In certain situations,
302 expensive additional equipment is not always required. In a study by Schmokel et al¹⁶ no
303 specific additional equipment was required in seven dogs with tibial fractures stabilized with
304 MIPO in which the application of a pre contoured plate was the sole device used in these
305 cases. Further studies are required to ascertain whether the degree of fracture alignment is
306 related with a detrimental outcome or not.

307

308 Interestingly, in our study, 50% of respondents either rarely or never used fluoroscopy when
309 attempting MIPO techniques. This may be a potential explanation as to why challenges to
310 adequate fracture reduction was listed as the most important perceived limitation to MIO &
311 MIPO. Previous studies have recommended the use of intraoperative fluoroscopy to improve
312 fracture alignment but suggest that the benefits should be weighed against the risks of
313 performing fluoroscopy.^{11,19,39,45} Currently, to the authors' knowledge, there are no specific
314 studies evaluating whether there is a significant benefit of intraoperative fluoroscopy in
315 fracture alignment when performing MIPO.

316

317 There are clear advantages and disadvantages for minimally invasive approaches to fracture
318 stabilization when compared with open approaches. That said, the human and veterinary
319 literature is not clear and often conflicting with regards to developing a cost benefit analysis
320 for these cases. For example, there is some evidence that operating times were not
321 statistically different when comparing MIPO and more traditional techniques in one
322 metaanalysis by Yu et al.⁴¹ However, another metaanalysis by Li et al.³⁷ showed that minimally
323 invasive approaches were associated with longer operating times. Nine percent of
324 respondents of our survey perceived that longer operating times was the most significant
325 perceived limitation to performing MIPO over a more traditional approach. One study in the
326 human literature³⁶ did show that the operating time was largely dependent on surgeon skill
327 and experience. The authors of this latter study concluded that an individual specific
328 approach should be used in each case despite the benefits shown with a MIPO approach over
329 an interlocking nail or open approach and rigid internal fixation.³⁶ Until clear evidence can be
330 provided that one approach is significantly more effective than another the authors would
331 suggest that a decision is based on a case by case basis. Further randomized controlled trials
332 are required before further conclusions can be made.

333

334 Both younger respondents and non-Diplomates were more likely to respond negatively when
335 asked if there were sufficient training opportunities for MIPO techniques. This mismatch
336 suggests that there is feeling amongst younger surgeons that more training opportunities in
337 MIPO would be beneficial. The ACVS have included a minimum number of minimally
338 invasive surgeries in their residency training programs to try to increase the exposure of
339 surgeons in training to these techniques.⁴² There is scope for this to be adopted into other
340 residency training programs to try to address this perceived lack of training opportunities as
341 well as the development of MIPO specific training courses.

342

343 Interestingly, multiple respondents highlighted that there was confusion in the literature as to
344 the exact definition of what techniques constituted MIO and MIPO. There is a danger as new
345 techniques continue to be developed that this situation only becomes more confusing and
346 highlights the potential need for a consensus to be developed.

347

348 *Limitations:*

349 By nature of the design there are limitations to this survey. Whilst this study attempted to
350 ascertain the perspectives of MIO and MIPO in veterinary practice the survey was only
351 circulated amongst a specific subpopulation of veterinary surgeons, namely ECVS and ACVS
352 Diplomates and residents and VOS members and only a proportion of these responded. The
353 response rate was similar to a previous survey conducted on minimally invasive surgery
354 perceptions. This potentially introduces an element of bias to the study. For example,
355 individuals who may have a specific interest in the topic would probably be more likely to
356 complete the survey compared to individuals who have no incentive, interest or requirement
357 to complete the survey. As with all survey-based studies there is likely to exist bias between
358 responders and non-responders, and between our target population and veterinary surgeons as
359 a whole.

360

361 A further limitation of our study was in the design of the questionnaires. It would have been
362 more prudent to simply create one survey that was circulated to every member of the study
363 population.

364

365 *Conclusion:*

366 Despite evidence of the benefits of MIO and MIPO over more traditional fracture
367 stabilization approaches, controversy still remains as to whether these techniques are superior
368 to open reduction and rigid internal fixation. Further prospective studies are needed to clarify
369 this position. Our survey has highlighted that significant barriers remain before the technique
370 is likely to be more widely adopted. There is also evidence that further training opportunities
371 would be welcomed when considering MIO and MIPO techniques. Currently MIO/MIPO
372 techniques are performed infrequently with most respondents revealing that they would like
373 to perform more in the future.

374 *Disclosure:*

375 The authors declare no conflict of interest to this report.

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386 **Table 1: Diplomat status vs responses to the question “How much MIO would you like**
 387 **to perform compared with your current level?”**

		The				
		Less	same	More	Exclusively	Total
Diplomate	Count	3	82	113	1	199
		2%	41%	57%	1%	
Non-						
Diplomate	Count	0	12	45	0	57
		0%	21%	79%	0%	

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400 **Table 2: Diplomat status vs responses to the question “How much MIPO would you**
 401 **like to perform when compared with your current level?”**

		Less	The same	More	Exclusively	Total
Diplomate	Count	2	73	102	1	178
		1%	41%	57%	1%	
Non-						
Diplomate	Count	2	8	49	1	60
		3%	13%	82%	2%	

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415 **Table 3: Diplomat status vs responses to the question “Do you feel there are sufficient**
 416 **training opportunities for the technique of MIPO?”**

		No				
		Yes	No	opinion	Other	Total
Diplomate	Count	47	65	65	1	178
		26.4%	36.5%	36.5%	0.6%	
Non-						
Diplomate	Count	9	39	10	2	60
		15%	65%	17%	3%	

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429 **Table 4: Age vs responses to the question “How much MIPO would you like to perform**
 430 **when compared with your current level?”**

		Less	The same	More	Exclusively	Total
21-50	Count	2	54	124	1	181
		1.1%	29.8%	68.5%	0.6%	
51-71+	Count	2	27	27	1	57
		4%	47%	47%	2%	

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444 **Table 5: Age vs responses to the question “Do you feel there are sufficient training**
 445 **opportunities for the technique of MIPO?”**

		No				
		Yes	No	opinion	Other	Total
21-50	Count	39	88	51	3	181
		21.5%	48.6%	28.2%	1.7%	
51-71+	Count	17	16	24	0	57
		30%	28%	42%	0%	

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