Prevalence of intraoperative and postoperative iatrogenic mandibular fractures after lower third molar extraction: A systematic review

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Abstract
Background: The surgical extraction of the lower third molars is one of the most common procedures in oral surgery, and this surgical operation can cause intra- and postoperative complications such as pain, trismus, bleeding, infection, oedema, inferior alveolar nerve injuries, displacement of teeth to neighbouring spaces and mandibular fractures. The aim of this systematic review is to report the prevalence of mandibular fractures that occur intra- and postoperatively in patients who have undergone surgical removal of the lower third molar.

Material and Methods: An electronic database search for articles published in Cochrane, PubMed (MEDLINE) and Scopus was conducted using the key words “Molar, Third”; “Mandibular Fractures”; “Molar Third, Removal”; “Molar Third, Complications”; “Dental Extractions, Complications”; “Mandibular Fractures, Third molar removal”. The inclusion criteria were articles including at least 10 patients and were published in English in the last 10 years. The exclusion criteria were nonhuman studies and case reports.

Results: Postoperative mandibular fractures after 3MI occur more frequently in male patients between the ages of 40 and 60 and are caused by premature chewing force. The parameters that most frequently characterise mandibular fractures at the mandibular angle are deeply impacted lower third molars, Class II and III, B and C, according to the Pell & Gregory classification system, mesioangular according to the Winter’s classification, and are located on the left mandibular side.

Conclusions: Mandibular fractures can be predicted with adequate preoperative planning for each case and identify the related risk factors for this complication.

Key words: Molar, Third; Mandibular Fractures; Molar Third, Removal; Molar Third, Complications; Dental Extractions, Complications; Mandibular Fractures, Third molar removal.
Introduction

Surgical extraction of the lower third molars is one of the most common procedures in oral surgery (1-4). This surgical procedure may be accompanied by intra- and postoperative complications such as pain, trismus, bleeding, infection, oedema, inferior alveolar nerve injuries, displacement of teeth to neighbouring spaces and mandibular fractures (1-6). The mandible has some weak areas that are less resistant to fractures such as the mandibular angle, the condyle, the mandibular symphysis, the body and coronoid process (7,8). The specific bone anatomy of the gonial angle with its location between the ascending branch and the mandibular body as well as its association with the inclusion of the lower third molar makes it one of the most frequent fracture sites (40%) (8,9).

Mandibular fractures are some of the severe lower third molar complications that can occur. This complication has a relatively low rate of incidence, ranging from 0.0034% to 0.075% for lower third molar extractions (1), and with similar percentages in the studies published by Joshi et al. (2), Boffano et al. (3) and Bodner et al. (5). In the study published by Grau-Manclús et al. (6), they report a narrower range from 0.0033% to 0.0046%, and Ethunandan et al. (4), establish an incidence of 0.00033% and 0.0049%. Postoperative fractures are the most common, with an incidence ranging from 0.0042% (7) to 0.0046% (10) in contrast with intraoperative fractures, which vary between 0.0033% (7) and 0.0036% of cases (6).

Mandibular fractures can occur intraoperatively or as a late complication during the postoperative course, generally within the first 4 weeks after surgery (2,5). Inadequate management of surgical instruments, the application of excessive force, incorrect surgical technique, understimating the difficulty of the extraction, not performing the correct odontosection of the lower third molar and performing extensive ostectomies may be some of the causes of iatrogenic fractures (3,7,11). In addition, areas of bone weakened by pathological processes such as cystic and/or malignant injuries, osteoporosis, osteomyelitis or medication-related osteonecrosis of the jaw caused by bisphosphonates are other possible causes of pathological fractures (3,10,11), with these making up less than 2% of all total mandibular fractures (3).

According to previously published studies, the cause of this complication is multifactorial, and it has been demonstrated there are different factors that may contribute to and increase the risk of this event. These include the age and gender of the patient, the position and angulation of the lower third molar, a possible previous infectious pathology associated with the tooth to be extracted, as well as postoperative care like consuming a soft food diet and moderate chewing (1,2,5).

The aim of this systematic review is to report the prevalence of intra- and postoperative mandibular fractures in patients who underwent surgical removal of lower third molars. The secondary objectives are to establish what the risk factors for this complication are and the most common location of these fractures.

In order to accomplish these objectives, a PICO question was formulated: What is the frequency, location and risk factors associated with the appearance of intra- or postoperative mandibular fractures in patients who require the removal of third molars?

Material and Methods

An electronic database search for articles published in Cochrane, PubMed (MEDLINE) and Scopus with the key words “Molar, Third”; “Mandibular Fractures”; “Molar Third, Removal”; “Molar Third, Complications”; “Dental Extractions, Complications”; “Mandibular Fractures, Third molar removal”, following the PRISMA flow diagram (Fig. 1) (12) was carried out. The inclusion criteria were systematic reviews and meta-analyses of cases of intra- or postoperative mandibular fractures after lower third molar removal, which included at least 10 cases, were published between 2005 and 2021, written in English, and analysed risk factors related to this surgical complication (Table 1). Articles published before 2005 and based on nonhuman studies in which mandibular fractures unrelated to the extraction of the lower third molar were reported (5,14,16) and series of less than 10 cases were excluded. The selected articles, classified according to their level of scientific evidence according to the SIGN criteria (17), are reflected on Table 1. They were analysed by two independent reviewers by first analysing the titles and summaries and then through full text examination (Table 1). Data collection was carried out independently, including copies of the original articles and data extraction in order to analyse demographic variables such as age and gender, aetiology, the intra- or postoperative period of the fracture (Table 2, 2 cont.), anatomical conditions like the position of the lower third molar (according to Pell & Gregory’s classification) (18), the angulation (Winter’s classification) (19), the degree of impaction (total or partial impaction), as well as the location of the fracture in the mandibular anatomy (Table 3, 3 cont.).

Results

706 studies were obtained from the initial search after eliminating duplicate articles, analysing the title and those which did not meet the previously established inclusion criteria. Of these, the full texts of 45 articles were analysed for their eligibility. Finally, an additional 34 articles were eliminated for not meeting the previously established inclusion criteria leaving 11 studies (1-7,10,11,13,15) (Table 2, 2 cont.) that are included in this systematic review whose objective is to analyse man-
Table 1: Studies selection according to the level of scientific evidence established by SIGN criteria (17).

| Studies            | Level of scientific evidence according to SIGN criteria | Type of study        | Number of participants | Number of reported fractures | Intra-/Postoperative fractures |
|--------------------|--------------------------------------------------------|----------------------|------------------------|------------------------------|--------------------------------|
| Pires et al. (1)   | 1++                                                    | Systematic review    | 124                    | 124                          | 61 postoperative               |
| Joshi et al. (2)   | 1+                                                     | Meta-analysis        | 200                    | 200                          | 44 intraoperative 130 postoperative |
| Boffano et al. (3) | 1+                                                     | Systematic review    | 187                    | 187                          | 23 intraoperative 81 postoperative |
| Ethunandan et al. (4) | 1-                                                   | Systematic review    | 130                    | 130                          | 32 intraoperative 86 postoperative |
| Bodner et al. (5)  | 2++                                                    | Systematic review    | 189                    | 189                          | 35 intraoperative 125 postoperative |
| Grau-Manclús et al. (6) | 2+                                                   | Cohort study         | 11                     | 11                           | 7 intraoperative 4 postoperative |
| Chrcanovic et al. (7) | 3                                                     | Systematic review    | 128                    | 128                          | 1 intraoperative 1 postoperative |
| Wagner et al. (10) | 2+                                                     | Cohort study         | 17                     | 17                           | 3 intraoperative 14 postoperative |
| Msagati et al. (11) | 3                                                      | Transversal study    | 896                    | 1                            | 1 intraoperative               |
| Kunkel et al. (13) | 2+                                                     | Cohort study         | 100                    | 110                          | 110 postoperative              |
| Kunkel et al. (15) | 2+                                                     | Cohort study         | 55                     | 6                            | Not referred                   |

Fig. 1: PRISMA flow diagram (12).
| Study                      | DEMOGRAPHIC VARIABLES | ETOILOGY AND TIMING                                      |
|----------------------------|-----------------------|--------------------------------------------------------|
|                            | Age                   | Gender                                                 | Etiology                                                                 | Timing                      |
| Pires et al. 2017 (1)      | 102 cases: 40-60 years old (34.3%) | 80 cases: 59 M (73.7%) 21 F (26.2%) | 46 cases: Premature and excessive occlusal forces: 35 (76.1%) Yawn: 3 (6.5%) Sport activities: 3 (6.5%) Accidental drop: 1 (2.2%) Car crash: 1 (2.2%) Osteomyelitis: 3 (6.5%) | 61 cases: Intraoperative: not referred Postoperative: 2 weeks: 32.8% 3 weeks: 27.9% 4 weeks: 18.0% |
| Joshi et al. 2016 (2)      | 177 cases: M/F: 2.2:1 | 177 cases: M/F: 2.2:1 | Not referred | 174 cases: Intraoperative: 44 (25%) Postoperative: 130 (75%) (1-5 weeks (86%)) |
| Boffano et al. 2013 (3)    | Mean age: > 40 years old | M/F: 2.2:1 | Premature and excessive occlusal forces: 71% | Intraoperative: 26% Postoperative: 74% |
| Ethunandan et al. 2012 (4) | 123 cases: Age range 26-79 years old More frequent: 30-50 years old Intraoperative: 26 to 79 years old Postoperative: 20 to 78 years old | 129 cases: Postoperative M more common (M/F: 3.9:1) Intraoperative: F more common (M/F: 1:1.3) | Not referred | 118 cases: Intraoperative: 32 cases Postoperative: 86 cases (between 1-70 days) More frequent: 2-3 weeks (57%) |
| Bodner et al. 2011 (5)     | 165 cases: 5th decade more affected | 165 cases: M/F: 2.2:1 | Not referred | 160 cases: Intraoperative: 35 cases Postoperative: 125 cases between 1-5 weeks More frequent: 1-3 weeks (86%) |
| Grau-Manclús et al. 2011 (6) | Age range 28-63 years old | 6 M 5 F | Postoperative: premature and excessive occlusal forces | Intraoperative: 4 cases Postoperative: 7 cases (Between 14-30 postoperative days) |
| Chrcanovic et al. 2010 (7) | Older than 40 years old: more affected | More frequent M | Premature and excessive occlusal forces and bruxism | Intraoperative: not referred Postoperative: between 1-4 weeks |
Table 2 cont.: Demographic variables (age and gender) (M: male gender F: female gender), etiology and timing of mandibular fractures (intraoperative or postoperative) (weeks (wk)) (1-7, 10, 11, 13, 15).

| Study                        | Demographic variables (age and gender) | Etiology and timing of mandibular fractures (intraoperative or postoperative) (weeks (wk)) |
|------------------------------|----------------------------------------|------------------------------------------------------------------------------------------|
| Wagner et al. 2005 (10)      | 17 cases: 40-69 years old more affected | Not referred                                                                             |
|                              | 17 cases: 16 M 1 F                      | 17 cases: 3 cases                                                                       |
|                              |                                         | 14 cases: 1-4 weeks: 11 cases                                                           |
|                              |                                         | 496 M (55.4%) 400 F (44.6%)                                                             |
| Msagati et al. 2013 (11)     | 896 cases: Age range 16-85 years old    | Not referred                                                                             |
|                              | 896 cases:                              | 1 postoperative fracture                                                                 |
|                              | Age range 16-85 years old               | 10 M 1 F                                                                                 |
| Kunkel et al. 2007 (13)      | 1/3 of the patients ≥ 40 years old      | Not referred                                                                             |
|                              | Age range 20-57 years old               | Not referred                                                                             |
| Kunkel et al. 2006 (15)      | Age range 14-86 years old               | Not referred                                                                             |

Table 3: Lower third molar position and description of the location of the fractures (anatomic location and affected side) (1-7, 10, 11, 13, 15).

| Study            | LOWER THIRD MOLAR POSITION | FRACTURE LOCATION |
|------------------|----------------------------|-------------------|
|                  | Pell&Gregory | Winter              | Degree of impaction | Fracture location | Fracture side |
| Pires et al. (1) | 39 cases:         | 75 cases:        | 54 cases: | Not referred | 67 cases: |
|                  | Class I: 4 (10.2%) | Distoangular: 9 (12%) | Totally impacted: 35 | Left: 35 (52.2%) | Left: 35 (52.2%) |
|                  | Class II: 24 (61.5%) | Horizontal: 14 (18.7%) | (64.8%) | Right: 30 (44.8%) | Right: 30 (44.8%) |
|                  | Class III: 11(28.2%) | Mesioangular: 27 (36%) | Partially impacted: 19 | Not referred | |
|                  | A: 2 (5.1%) | Vertical: 25 (33.3%) | (35.2%) | Not referred | |
|                  | B: 16 (41.0%) |                      |                  | Not referred | |
|                  | C: 21 (53.8%) |                      |                  | Not referred | |
| Joshi et al. (2) | Not referred | 137 cases: | 138 cases: | 182 cases: | 182 cases: |
|                  | Distoangular: 12% | Totally impacted: 54% | Mandibular angle: 136 | Left: 93 (51%) | Left: 93 (51%) |
|                  | Horizontal: 27% | Partially impacted: 30% | Mandibular body: 40 | Right: 89 (49%) | Right: 89 (49%) |
|                  | Mesioangular: 28% | Submucosal inclusion: 16% | (22%) | |
|                  | Vertical: 33% |                  | Canine area 16 (3%) |                  | |
| Boffano et al. (3)| Not referred | More frequent horizontal/mesioangular than vertical/distoangular | Totally impacted lower third molar: more fracture incidence | Not referred | Not referred |
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Table 3 cont.: Lower third molar position and description of the location of the fractures (anatomic location and affected side) (1-7,10,11,13,15).

| Study             | Cases | Intraoperative | Postoperative | Mandibular angle |
|-------------------|-------|----------------|---------------|------------------|
| Ethunandan et al. (4) | 41 cases | More frequent: Class II/III and B/C | Not referred | Not referred |
|                   |       | Intra- and postoperative more frequent: Class II and C | | |
| Bodner et al. 2011 (5) | 123 cases | Distoangular: 16 (13%) Horizontal: 32 (26%) Mesioangular: 30 (24%) Vertical: 45 (37%) | Not referred | Not referred |
| Grau-Manclús et al. 2011 (6) | Class I: - Class II: 8 cases Class III: 3 cases A: - B: 2 cases C: 9 cases | Distoangular: Horizontal: 5 cases Mesioangular: 5 cases Vertical: 1 case | Not referred | Not referred |
| Chrcanovic et al. 2010 (7) | More frequent: Class II/B | More frequent: dis-toangular | Not referred | Mandibular angle |
| Wagner et al. 2005 (10) | 10 cases: Class I: - Class II: 3 cases Class III: 7 cases A: 1 case B: 5 cases C: 4 cases | 10 cases: Distoangular: 2 cases Horizontal: Mesioangular: 2 cases Vertical: 6 cases | 10 cases: Totally impacted: 4 cases Partially impacted: 6 cases | Not referred |
| Msagati et al. 2013 (11) | Not referred | Not referred | Not referred | Mandibular angle |
| Kunkel et al. 2007 (13) | Not referred | Not referred | Not referred | Not referred |
| Kunkel et al. 2006 (15) | Not referred | Not referred | Not referred | Not referred |

dem fractures as intra-or postoperative complications as a result of third molar extraction (Fig. 1). Demographic variables, age and gender were documented in all the studies that were included (1-7,10,11,13,15). They report that the highest frequency of mandibular fractures occurs in male patients (91.6%). Only one study established that intraoperative fractures occur more frequently in female patients, in contrast with postoperative fractures, which occur more commonly in men (4). The most affected patients were over 40 ranging between 40 and 60 years of age (66.66%) (1-5,7,10,13) and in 4 studies (6,11,15), the age range varied greatly from 16 to 86 years of age (33.33%) (Table 2, 2 cont.). With regard to aetiology and the timing of the fractures, it was observed that the intraoperatively inappropriate use of surgical instruments (6), premature postsurgical occlusal force (80%) (1,3,6,7) and bruxism (7), are the main aetiological factors associated with these fractures. It should be noted that these factors were not reported in 8 of the 11 studies included in the analyses (2,4,5,10,11,13-15). The time of fracture on-
Discussion

Mandibular fractures related with the extraction of lower third molars are one of the most severe complications that can occur intra- or postoperatively. It can occur as an immediate or a late complication, generally within the first 4 weeks after the removal of 3MI (2-7,10). According to Pires et al. (1), the greatest period of risk is during the second and third postoperative weeks, since the granulation tissue in the alveolus is being replaced by connective tissue and the resistance of the mandibular bone is decreased during this time.

With regard to age and gender, 91.6% of fractures occurred in male patients (1-3,5,11) over 40 years old, with a range established between 40 and 60 years of age (1,7,10,13). According to Bodner et al. (5) and Özçakir-Tomruk et al. (31), this may be due to a delay in the maturation phase during the bone regeneration period and the weakening of bone tissue associated with a reduction in bone elasticity during the aging process starting in the fourth decade of life. Likewise, Perry and Goldberg (30) highlight a delay in the bone granulation phase in older patients where two thirds of the socket are not filled with osteoid material, thereby causing a decrease in the resistance of the mandibular bone.

Pires et al. (1) mention that the decrease in bone elasticity and the appearance of osteoporosis in elderly patients may be another reason. Elderly patients experience greater thinning of the periodontal ligament and the incidence of ankylosis also increases which can increase the difficulty in removing the lower third molars, creating a considerable need for ostectomies which facilitate the chances of a possible fracture. With regard to gender, it has been noted that males have greater muscular strength which favours the appearance of excessive traction force during the postoperative course (32-34).

Fractures that occur during surgery are less frequent than postoperative ones (5,7,10). Intraoperative factors related with this complication are the inappropriate use of surgical instruments, incorrect surgical techniques in which excessive force is exerted (6), a mesioangular position of the lower third molar (4,8,30,35,36) probably due to the fact that mesioangular and vertical angulations are more prevalent in the general population as highlighted by Morales-Trejo et al’s study (37), and a relationship with the anterior zone of the mandibular ascending ramus type II and III, and Pell & Gregory’s depths B and C (18) (1-7,10,14). Pires et al. (1) claim that this is probably attributed to a greater degree of difficulty in extracting the lower third molar, making more extensive ostectomies necessary. These authors also mention the relationship between postoperative mandibular fractures and a history of pericoronitis, which could be related to the fact that recurrent or chronic infections can contribute to decalcification and, therefore, a greater probability of fracture (1). Ethunandan et al. (4) and Grau-Manclú’s et al. (6) established the use of Winter’s drift as an inappropriate instrument, since it has a shorter stem and a thicker handle making it easy to apply excessive force with the first application of the first-class lever.

Perry and Goldberg (30) mention that a bone area with a weakened structure is created after extracting the lower third molars making the appearance of this type of complication more likely. Though intraoperative fractures are less frequent, 7 of 11 mandibular fractures were inoperable in the Grau-Manclú’s et al. study (6). This may be because five of the intraoperative fractures occurred in lower third molars associated with dentigerous cysts and odontogenic tumours. These alterations can cause significant weakening of the bone, particularly in the region of the mandibular angle. It can therefore be concluded that there is a relationship between the presence of pathological bone changes and the subsequent appearance of fractures.

In the study published by Wagner et al. (10), of 17 fractures, 12 occurred on the left side which may be attributed to worsened view of the surgical field from the surgeon’s right side, resulting in a less extensive ostectomy.
With regard to the degree of impaction, Chrccanovic and Custodio (7), relate it to a surgical approach that includes quite extensive ostectomies, thereby favouring fractures at the level of the mandibular angle (11,36-38). According to Perry and Goldberg (30), the risk of fracture is higher in the first 2 to 3 weeks of the postoperative course therefore fractures occurring in the immediate or late postoperative period are more frequent than intraoperative ones (1-7,10,11). Premature and excessive occlusal force have been associated with this complication. Pires et al. (1), affirm that the masticatory force necessary to break down food before swallowing it can generate a considerable amount of tension in the weakened mandibular region after lower third molar extraction. Perry and Goldberg et al. (30) reported that mandibular fractures occurred in patients who did not correctly follow the postoperative instructions for a soft food diet. Libersa et al. (8), claim that patients abandoned the soft diet and resumed daily activities and physical sport in the first 2-3 weeks of the postoperative course as their general condition and symptoms improved making these sorts of fractures are more frequent. Joshi et al. (2) discusses the possibility that postoperative fractures may be incomplete intraoperative fractures, which may have exceeded the tolerance of stress limits in the weeks after the extraction, given that patients felt better and painful symptoms had almost disappeared at the end of the second week.

The risk of impaired sensitivity of the inferior alveolar nerve should also be analysed when fractures during the extraction of the lower third molar occur. Boffano et al. (40) analyse the incidence of inferior alveolar nerve injuries after the incidence of mandibular fractures at the body level, the angle or the mandibular ascending branch or after traumatic events such as car accidents or other traumatic events in 325 hospital patients. Patients with condylar fractures and comminuted or multiple fractures were excluded. Finally, 79 patients (24.3%) with inferior alveolar nerve alterations were included in the study. These sensory alterations were analysed by means of a two-point discrimination test, using the non-fractured side of the same patient as a control. Patients diagnosed with hypoesthesia, paraesthesia, or anaesthesia were included. No statistically significant relationship was found between the occurrence of changes in sensitivity as a result of an inferior alveolar nerve injury in relation to a mandibular fracture, but its association with traumatic injuries caused by trauma in the mandibular region was significant.

Tay et al. (41), described neurosensorial alterations that occurred in 80 patients who had experienced mandibular fractures as a result of traumatic events; 49.3% of the fractures caused an alteration in the sensitivity of the inferior alveolar nerve, while fractures at the condylar level (13%) were not associated with episodes of sensory alterations. The overall prevalence of inferior alveolar nerve injuries was 33.7%, before the surgical approach to mandibular fractures, and 53.8% after fracture reduction and fixation using titanium miniplates. According to this study, one of the risk factors associated with the development of these injuries after a mandibular fracture was related to the type of surgical approach used to reduce the fracture and the separation distance between the reduced fragments. According to this study, a distance greater than 1 mm results in a 27% increase in the probability of postoperative sensory alterations. The factors determining the recovery time after an alteration in the sensitivity of the inferior alveolar nerve include the type of surgical approach used to reduce and fix the fracture for its consolidation, the location of the fracture in the region of the mandibular angle, the time elapsed between the fracture event and its surgical reduction, as well as the patient’s age. Therefore, mandibular fractures in the posterior mandibular region exhibit a high prevalence of associated neurosensorial disorders (56.2%). Risk of injury to the inferior alveolar nerve should be considered for all patients who have had a mandibular fracture, either in the intra- or postoperative course after lower third molar removal, resulting from the displacement of both fractured fragments and during the surgical reduction approach. These patients should be advised that these sensory changes can occur in the postoperative period, and that in order to accelerate and promote sensory recovery, it is necessary to implement a pharmacological treatment associated with the application of low-level laser therapies (42,43).

Finally, the results obtained in this systematic review of 11 studies should be relativized by taking into account that 3 of the included studies (5,6,11) had a low level of evidence according to the Scottish Intercollegiate Guidelines Network criteria for evaluating scientific evidence (SIGN) (17), which are reported on Table 1. The exclusion criteria also had case series of less than 10 patients due to their limited level of evidence. In addition, it has been observed in the studies we analysed, that there are numerous parameters that were not reported for analysis, such as the aetiology of the intra- or postoperative fracture, characteristics of the extracted lower third molar (in terms of their three-dimensional position, such as the degree of impaction) in addition to the location of the fracture itself.

Conclusions
Considering the limitations of this study, it can be concluded that a comprehensive preoperative analysis of the frequency of different risk factors related to mandibular fractures occurring after the removal of the 3MI is necessary. It should include demographic variables like age and gender, the planning of the surgical technique according to the position, angulation and degree of impaction.
of the 3MI. There is an increased risk of intraoperative and postoperative mandibular fractures after the extraction of 3MI in male patients over 35 years old, with fully impacted 3MI that are mesio-angulated and classified as II or III and B or C, according to Pell & Gregory and Winter classification systems. The mandibular angle is the most frequent location of intraoperative and postoperative fractures, followed by the mandibular body and the canine area.

Moreover, intraoperative mandibular fractures occur more frequently on the left mandibular side, unlike postoperative ones, which occur more frequently on the right side. A detailed clinical and radiographic study of each case and employing adequate surgical techniques are the most relevant strategies in preventing the appearance of mandibular fractures after the extraction of 3MI.

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Conflicts of interest
The authors have declared that no conflict of interest exist.