# Canine retraction: A systematic review of different methods used

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## ABSTRACT

Canine retraction is a very important step in treatment of patients with crowding, or first premolar extraction cases. In severe crowding cases until, the canines have been distilized to relive the crowding, space to correctly align the incisors will not be available. Correct positioning of the canines after retraction is of great importance for the function, stability, and esthetics. The aim of this systematic review was to examine, in an evidence-based way, which kinds of canine retraction methods/techniques are most effective and which have the least side effects. A literature survey was performed by applying the Medline Database (Entrez PubMed) and Science Direct database covering the period from 1985 to 2014, to find out efficient ways to accomplish canine retraction. Randomized controlled trials (RCTs), prospective and retrospective controlled studies, and clinical trials were included. Two reviewers selected and extracted the data independently and assessed the quality of the retrieved studies. The search strategy resulted in 324 articles, of which 22 met the inclusion criteria. Due to the vast heterogeneity in study methods, the scientific evidence was too weak to evaluate retraction efficiency during space closure. The data so far reviewed proved that elastomeric power chains, elastic threads, magnets, NiTi coil springs, corticotomies, distraction osteogenesis, and laser therapy, all are able to provide optimum rate of tooth movements. All the methods were nearly similar to each other for retraction of canines Most of the techniques lead to anchorage loss in various amounts depending on the methods used. Most of the studies had serious problems with small sample size, confounding factors, lack of method error analysis, and no blinding in measurements. To obtain reliable scientific evidence, controlled RCT's with sufficient sample sizes are needed to determine which method/technique is the most effective in the respective retraction situation. Further studies should also consider patient acceptance and cost analysis as well as implants and minor surgeries for canine retraction.

**Key words:** Canine retraction, extractions, space closure

## INTRODUCTION

There has always been a conflict between extraction and non extraction treatments in orthodontics.[1-3] This debate is never ending. Extraction treatment has gained popularity from 1930s.[4] This was to achieve a more stable result.[5] Premolars were chiefly considered for extraction followed by canine retraction.[6-9] Since space closure is a routine procedure in orthodontics, researchers have always tried to find efficient methods for canine retraction.[10]

Canines can be retracted by two ways:

- Frictional (sliding) mechanics
- Non frictional (non sliding) mechanics.

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Frictional mechanics is the sliding of a tooth along an arch wire by application of force.[11]

Non frictional mechanics uses loops for tooth movement (non sliding). Canines can be retracted individually or can be retracted along with the incisors. Retraction of the canines along with the anterior teeth as one unit is known as en masse retraction. Both techniques depend on the type of malocclusion and operators' skill and preference. To date, several studies have been published concerning different techniques of canine retraction with the aspect of the application, mechanics, or

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effectiveness. However, it can be difficult for the practitioner to interpret the results and evidence presented in these studies because a variety of study designs, sample sizes, and research approaches. In view of this, a systematic review of the present knowledge seems desirable.[12] This systematic review was undertaken to answer the following questions.

- What kind of canine retraction methods/techniques are evaluated in an evidence-based manner?
- How effective and efficient are the different methods of retraction?
- Which technique retracts the canine in the least amount of time and the most physiological way?

### Risk of Bias

Two reviewers (Drs. Kulshrestha and Chandra) [Table 1] independently assessed all the articles with respect to the inclusion and exclusion criteria, and the kappa score measuring the level of agreement was 0.94 (very good).[13] Any inter examiner conflicts were resolved by discussion to reach consensus.

## MATERIALS AND METHODS

Reporting of this systematic review was performed in accordance with the PRISMA guidelines for reporting systematic reviews of health sciences interventions.[14] Three hundred and twenty-two articles were searched to find the most efficient ways to retract the canines. To identify all the studies that examined canine retraction and their effectiveness, a literature survey was done by applying the Medline Database (Entrez PubMed) and Science Direct database covering the period from 1985 to 2014, and used the Medical Subject Heading term "orthodontics" and was crossed with a combination of the following term "retraction." A flow diagram of the data search can be seen in Figure 1.

The inclusion criteria for the articles were:

- All journal articles, including clinical trials, abstracts
- *In vivo* human studies
- Studies with first maxillary or mandibular premolar extractions
- Similar methodology applied for measurement of tooth movement in all the studies.

**Table 1: Kappa scores measuring levels of agreement between the two reviewers in assessing data extraction and quality scores of the included articles[a]**

| Type | Kappa value | Level of agreement |
|---|---|---|
| Study design | 0.97 | Very good |
| Sample size | 1.0 | Very good |
| Selection description | 1.0 | Very good |
| Valid measurement methods | 1.0 | Very good |
| Method error analysis | 0.75 | Good |
| Blinding in measurements | 1.0 | Very good |
| Adequate statistics provided | 0.72 | Good |
| Confounding factors | 0.77 | Good |
| Judged quality standard | 0.94 | Very good |

[a]Kappa values – 0.20: 5 poor, 0.21–0.40: 5 fair, 0.41–0.6: 5 moderate, 0.61–0.8: 5 good, 0.81–1.0: 5 very good

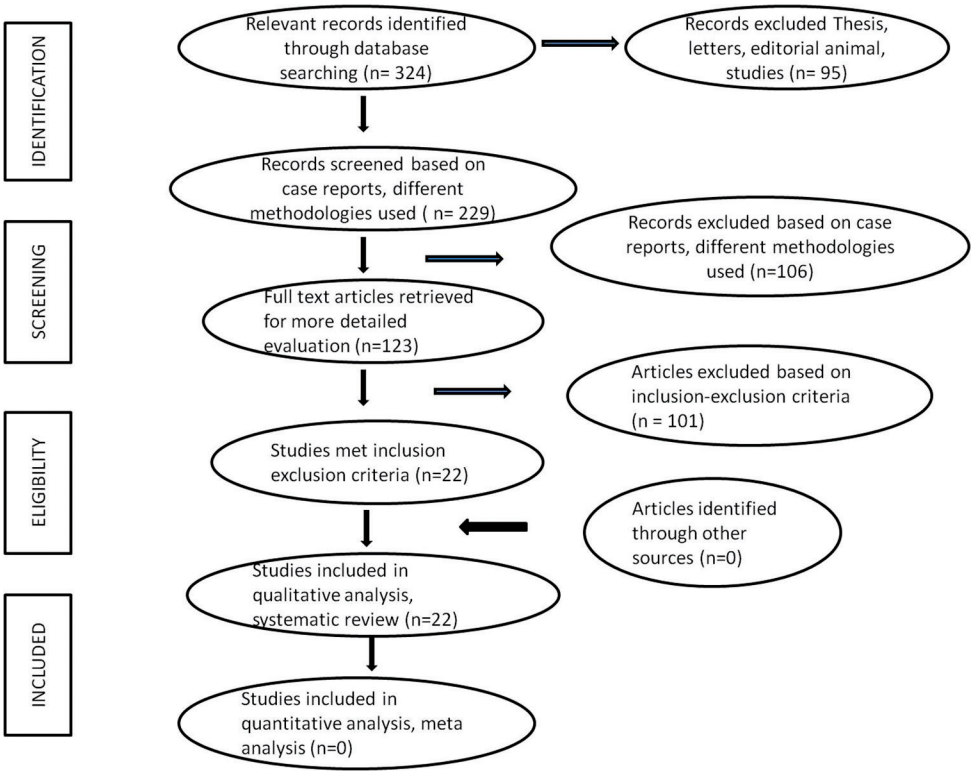


**Figure 1:** Flow diagram of data search according to PRISMA

The exclusion criteria included [Table 2].

- Thesis, letters, editorials, case reports where no abstract was available
- All animal studies
- Nonextraction or extraction of teeth other than first premolar
- Studies with different methodologies applied for the measurement of tooth movement.

## Methodology

To identify all the studies that examined the relationship between the type of force applied and resultant canine retraction, a literature survey was done. No restrictions were set for the sample size. Only *in vivo* human studies that have undergone 1st premolar extraction followed by canine retraction were included. Age and gender restrictions are not applied.

Data were collected and analyzed according to these headings:

- Journal, of Publication
- Study design
- Sample size
- Type of force application
- Magnitude of force
- Rate of canine retraction
- Side effects.

Limitations that were seen are also discussed and analyzed.

Twenty-two articles were finally reviewed to calculate the effectiveness of different methods of canine retraction.[15-36]

## RESULTS

Retraction evaluated at leveling and alignment stages, application of different techniques for rapid distalization of canine such as distraction osteogenesis, laser therapy, and corticotomies before canine retraction, are all included in the review. All articles were randomized controlled trials (RCTs) with a split-mouth study design for better correlation [Table 3].

Huffman and Way[15] compared wires of two different sizes 0.016 and 0.020 stainless steel (SS) and found out no difference. Cacciafesta *et al.*[24] compared elastomeric auxiliaries in the form of Unitek Alastik chain, Rocky Mountain elastic chain, and Elastic thread and found out that there was no difference between the three. Ziegler and Ingervall[17] compared frictional with frictionless mechanics; they compared elastic chain with Gjessing retraction spring and also compared Rickett's retraction spring with NiTi coil spring. They found out that with springs rotation is less and tipping is more.

Samuels *et al.*[18,21] performed one study comparing medium NiTi coil spring with elastic module. They further compared the light, medium, and heavy NiTi coil springs with elastic modules to establish which treatment modality was more effective. Three more studies were reviewed, which compared elastomeric auxiliaries with NiTi coil spring.[21-23] Daskalogiannakis and McLachlan[20] evaluated the rate of canine retraction with reference to a continuous or an interrupted force delivery with magnets and a vertical loop, respectively. Two studies compared the tipping with bodily mechanics.[17,24] Deguchi *et al.*[26] explained the difference between steel ligatures tied plastic bracket with a metal slot and frictionless Clear Snap brackets. Forces were in the range of 70–450 g with a mean of 150–200 g. NiTi coil spring produced a continuous force for the required interval, whereas elastomeric auxiliaries had declining force application.[27] Three studies showed NiTi coil spring produced a faster rate of canine retraction.[20-22] Nightingale and Jones showed power chains to be as efficient as NiTi coil springs for retraction.[23]

**Table 2: Exclusion criteria and number of excluded articles in this systematic review**

| Exclusion criteria | Number of articles excluded |
|---|---|
| Thesis, letters, editorials | 72 |
| Animal studies | 23 |
| Case reports where no abstract was available | 50 |
| Studies with different methodologies applied for the measurement of tooth movement | 56 |
| Nonextraction or extraction of teeth other than first premolar | 101 |
| Total | 302 |

Elastic chain compared with Paul Gjessing retraction spring and Rickett's retraction spring compared with NiTi coil spring proved that there was no considerable difference in rates of canine retraction.[15] One study showed elastic chain, Rocky Mountain elastic chain and elastic thread to be as effective in retracting canines.[16] One study showed that rate of retraction was quite similar when size of the round wire was increased from 0.016" SS to 0.020" SS.[15] When tipping mechanics was compared with bodily mechanics one study reported no significant difference,[17] whereas Shpack *et al.*[28] showed a shorter duration of space closure with tipping mechanics. Thiruvenkatachari *et al.*[29] found that canine retraction using implants was very effective. Martins *et al.*[31] and Mehta and Sable[36] found that loops made of titanium molybdenum alloy wire were more effective than loops made of SS wires. Kharkar and Kotrashetti[33] and Raj and Kumar[35] found that distraction osteogenesis for canine retraction was a promising technique. Corticotomy assisted canine retraction proved to be very efficient.[34] Sukurica *et al.*[27] used segmental alveolar distraction technique for canine retraction using distractors and raising of the flap. They retracted the canine by 3 mm/month way faster than any other technique. Youssef *et al.*[30] irradiated the canine region with a low-level laser before retraction in their patients. They found that accelerated tooth movement was seen, and the pain felt during orthodontic movement was greatly reduced. Low-level laser therapy can highly accelerate tooth movement

**Table 3: Different methods of canine retraction**

| Article, journal | Year | Study design | Sample size | Force applied | Magnitude of force | Rate of canine retraction | Side effects | Conclusions |
|---|---|---|---|---|---|---|---|---|
| Huffman and Way, Am J Orthod[15] | 1986 | Split-mouth | 16 | 0.016" versus 0.020" SS<br>Force applied with a pletcher spring | 200 g | 1.37 mm/month and 1.20 mm/month | Tipping with small sized wire was more than larger wire | NS* difference between the two wire sizes |
| Sonis *et al.*, Am J Orthod[16] | 1986 | Split-mouth | 25 | Unitek Alastik chain<br>Rocky mountain chain<br>Elastic thread | 350-400 g | 1.28 mm/3 weeks<br>1.51 mm/3 weeks<br>1.55 mm/3 weeks | Force degradation of all the elastomeric auxiliaries occurred | NS difference |
| Ziegler and Ingervall, Am J Orthod Dentofacial Orthop[17] | 1989 | Split-mouth | 21 | Alastic chain<br>Gjessing retraction spring | 380 g<br>Initial decaying to 200 g<br>160 g | 1.4 mm/ 3-4 weeks<br>1.91 mm/ 3 weeks | Tipping, rotation of canine and anchorage loss of molars | NS difference with spring tipping is less and rotation is more |
| Samuels *et al.*, Am J Orthod Dentofacial Orthop[18] | 1993 | Split-mouth | 17 | NiTi spring<br>Elastic module | 150 g<br>400-450 g | Not mentioned | Force degradation with elastic module | Spring delivers a greater and more consistent force than elastic module |
| Lotzof *et al.*, Am J Orthod Dentofacial Orthop[19] | 1996 | Split-mouth | 12 | Tipedge bracket versus edgewise bracket<br>Force applied with power chain | 200 g | 1.88 mm/3 weeks<br>1.63 mm/3 weeks | More tipping with tip edge<br>Anchorage loss inconclusive due to small sample size | NS difference |
| Daskalogiannakis and McLachlan, Am J Orthod Dentofacial Orthop[20] | 1996 | Split-mouth | 6 | Vertical loop<br>Magnets | 70 g | 0.63 mm/28 days<br>1.62 mm/28 days | Not mentioned | Light force of a continuous nature is most efficient for tooth movement |
| Samuels *et al.*, Am J Orthod Dentofacial Orthop[21] | 1998 | Split-mouth | 18 | NiTi coil spring<br>Light/medium/heavy<br>Elastic module | 100 g<br>150 g<br>200 g | 0.16 mm/week<br>0.26 mm/week<br>0.24 mm/week<br>0.19 mm/week | Constant force<br>Force degradation | Medium and heavy spring produces a faster and consistent rate of space closure than the light spring or elastic module |
| Dixon *et al.*, J Orthod[22] | 2002 | RCT | 12<br>10<br>11 | Active ligatures<br>Power chain<br>NiTi coil springs | 200 g | 0.35 mm/month<br>0.58 mm/month<br>0.81 mm/month | Force value declines after few weeks<br>Heavy forces<br>Constant and light forces | Fastest with NiTi coil spring<br>However, power chin provides with an equally effective and cheaper alternative |
| Nightingale and Jones, J Orthod[23] | 2003 | RCT | 22 | Elastomeric power chain<br>NiTi coil spring | 209-109 g<br>300-149 g | 0.21 mm/week<br>0.26 mm/week | Modest sample size, timing of space closure, many variables which could not be standardized | NS difference |
| Cacciafesta *et al.*, Am J Orthod Dentofacial Orthop[24] | 2003 | Split-mouth | 8 | Ricketts spring<br>NiTi coil spring | 1 N | 1.91 mm/30 days<br>1.41 mm/30 days | Small sample size | NS difference |
| Bokas and Woods, Aust Orthod J[25] | 2006 | Split-mouth | 12 | NiTi coil spring<br>Power chain | 200 g | 1.85 mm/month<br>1.68 mm/month | Anchorage loss | Similar rates by both the methods |
| Deguchi *et al.*, Angle Orthod[26] | 2007 | Split-mouth | 30 | Plastic brackets with metal slot Clear Snap brackets | Force applied with closed coil spring | Not mentioned time measured instead | Not mentioned | Clear Snap brackets closed space quicker due to increased rate of canine retraction |
| Sukurica *et al.*, Angle Orthod[27] | 2007 | Split-mouth | 8 | Segmental alveolar distraction | 250 g | 3 mm/1-month | Distal tipping of canine<br>Anchorage loss | Quick and efficient technique |

Contd.,

**Table 3: Contd**

| Article, journal | Year | Study design | Sample size | Force applied | Magnitude of force | Rate of canine retraction | Side effects | Conclusions |
|---|---|---|---|---|---|---|---|---|
| Shpack *et al.*, Angle Orthod[28] | 2008 | Split-mouth | 14 | Tip edge bracket<br>Edgewise bracket<br>Force applied with NiTi coil spring | 0.5-0.75 N | Not mentioned | Rotation and anchorage loss tipping was not followed by root uprighting in tip edge | Tipping mechanics closed space in lesser tome than bodily mechanics |
| Thiruvenkatachari *et al.*, Am J Orthod Dentofacial Orthop[29] | 2008 | Split-mouth | 12 | Closed coil spring with implant anchorage | 100 g | 4.29 mm on implant anchorage side<br>3.7 mm on the control side | Not mentioned | Canine retraction proceeds faster when titanium micro implants are used for anchorage |
| Youssef *et al.*, Lasers Med Sci[30] | 2008 | Split-mouth | 15 | One side laser irradiation<br>Other side control | 200 g | 2 mm/2 months | Anchorage loss | Pain was reduced greatly in the laser irradiated side then control |
| Martins *et al.*, Am J Orthod Dentofacial Orthop[31] | 2009 | Split-mouth | 10 | 17×25<br>Beta titanium alloy<br>T-loop | 150 g | 3.2 mm/8 weeks | Cusp tips intruded<br>Apices were protruded | NS difference |
| Xu *et al.*, Am J Orthod Dentofacial Orthop[32] | 2010 | Split-mouth | 64 | En masse retraction lace backs | Not mentioned | 4.3 mm | Anchorage loss | NS difference |
| | | | | 2 step retraction lace backs | | 4.1 mm | Root resorption | |
| Kharkar and Kotrashetti, Oral Surg Oral Med Oral Pathol Oral Radiol Endod[33] | 2010 | Split-mouth | 6 | Dentoalveolar distraction<br>Distractors | 100 g | 6.5 mm/12 days | Tipping<br>Anchorage loss | Distraction osteogenesis for rapid tooth movement is promising |
| Aboul-Ela *et al.*, Am J Orthod Dentofacial Orthop[34] | 2011 | Split-mouth | 13 | Closed NiTi coil spring<br>Corticotomy assisted | 150 g | 5.88 mm/ 4 months | Not mentioned | Corticotomy assisted retraction is more efficient |
| | | | | Control without corticotomy | 150 g | 3.38 mm/ 4 month | | |
| Raj and Kumar, J Ind Orthod Soc[35] | 2013 | Split-mouth | 5 | Intraoral distractor | 200 g | 0.8 mm/day | Tipping | Significant reduction in total treatment time |
| Mehta and Sable, J Ind Orthod Soc[36] | 2013 | Split-mouth | 15 | 17×25 TMA T-loop | 200 g | 5.46 mm/ 4 months | Less rotational control | TMA loop retraction offers more canine retraction and more tipping control |
| | | | | 16×22 SS T-loop | 200 g | 4.20 mm/ 4 months | More tipping | SS loop offers more rotational control |

*NS – Not significant; TMA – Titanium-molybdenum alloy; SS – Stainless steel; RCT – Randomized clinical trial

during orthodontic treatment and can effectively reduce pain level.[36,37]

### Side Effects

Tipping was reported with quite a few studies[15,17] especially when wire of small diameter was used.[16] With power chain force degradation was reported.[18] The degradation of force was overcome by increasing the initial force application.[17] Rotation of canine and tipping affected the rate of canine measurement[15,17,24] and sample sizes were inconclusive to many studies. Root resorption was also seen in some of the studies along with increased anchorage loss.[23]

Risk of bias assessment of the 22 selected reports, 17 were retrospective studies, 3 were prospective studies, and 2 RCTs were present [Table 4].

## DISCUSSION

The strict inclusion and exclusion criteria applied for the present review may have resulted in a few articles. However, strength of the evidence in a review is more dependent on the quality of the included studies than on the degree of completeness.[31] Since different types of forces are applied within the same arch wire, it is believed the arch wire may twist under the influence.[22] This might have affected the results of rate of retraction in these studies. In such clinical trials, it is difficult to keep the variables of individual response, fluctuations of oral environment, lapses between appointments, precise and repeatable method of measurement of the rate of canine retraction, the force systems, could not be compared accurately.[18,22] Some believe that the varied response to different methods of canine retraction was not dependent on the type of force; rather it was due to individual metabolic response.[17]

**Table 4: Quality evaluation of the selected studies**

| Author (year) | Study design | Sample size | Selection description | Valid measurement methods | Method error analysis | Blinding in measurements | Adequate statistic provided | Judged quality standard |
|---|---|---|---|---|---|---|---|---|
| Huffman and Way 1986 | Retrospective comparative split-mouth | Inadequate | Adequate | Yes | Yes | No | Yes | Low |
| Sonis *et al.* 1986 | Retrospective comparative split-mouth | Adequate | Adequate | Yes | Yes | No | Yes | Medium |
| Ziegler and Ingervall 1989 | Retrospective comparative split-mouth | Inadequate | Inadequate | Yes | Yes | No | Yes | Low |
| Samuels *et al.* 1993 | Retrospective comparative split-mouth | Inadequate | Adequate | No | No | No | Yes | Low |
| Lotzof *et al.* 1996 | Retrospective comparative split-mouth | Inadequate | Adequate | Yes | Yes | No | Yes | Low |
| Daskalogiannakis and McLachlan 1996 | Retrospective comparative split-mouth | Inadequate | Inadequate | Yes | Yes | No | No | Low |
| Samuels *et al.* 1998 | Retrospective comparative split-mouth | Inadequate | Adequate | Yes | Yes | Yes | No | Medium |
| Dixon *et al.* 2002 | Randomized controlled clinical trial | Adequate | Adequate | Yes | No | Yes | Yes | High |
| Nightingale and Jones 2003 | Randomized controlled clinical trial | Adequate | Adequate | Yes | No | Yes | Yes | High |
| Cacciafesta *et al.* 2003 | Prospective comparative split-mouth | Inadequate | Adequate | Yes | No | No | Yes | Low |
| Bokas and Woods 2006 | Retrospective comparative split-mouth | Inadequate | Adequate | Yes | Yes | No | No | Low |
| Deguchi *et al.* 2007 | Retrospective comparative split-mouth | Adequate | Adequate | Yes | No | No | Yes | Medium |
| Sukurica *et al.* 2007 | Retrospective comparative split-mouth | Inadequate | Inadequate | Yes | Yes | No | Yes | Low |
| Shpack *et al.* 2008 | Retrospective comparative split-mouth | Inadequate | Adequate | Yes | Yes | No | No | Low |
| Thiruvenkatachari *et al.* 2008 | Retrospective comparative split-mouth | Inadequate | Adequate | Yes | No | No | Yes | Low |
| Youssef *et al.* 2008 | Prospective comparative split-mouth | Inadequate | Adequate | Yes | Yes | No | Yes | Low |
| Martins *et al.* 2009 | Retrospective comparative split-mouth | Inadequate | Adequate | No | Yes | No | Yes | Low |
| Xu *et al.* 2010 | Retrospective comparative split-mouth | Adequate | Adequate | Yes | No | No | Yes | Low |
| Kharkar and Kotrashetti 2010 | Retrospective comparative split-mouth | Inadequate | Adequate | Yes | No | No | Yes | Low |
| Aboul *et al.* 2011 | Retrospective comparative split-mouth | Inadequate | Adequate | Yes | Yes | No | No | Low |
| Raj and Kumar 2013 | Retrospective comparative split-mouth | Inadequate | Adequate | Yes | Yes | No | Yes | Low |
| Mehta and Sable 2013 | Prospective comparative split-mouth | Inadequate | Adequate | Yes | No | No | No | Low |

Sample size generally applied for these clinical trials was considered conclusive in a few researches.[19,20] Optimum force for movement has no specific value.[32] However, a range of 100–200 g is suggested sufficient by Quinn and Yoshikawa[12,17,33] and this was the force range observed in the review. It is not the magnitude of force applied rather its duration that is considered important for good biologic tooth response.[18] Light continuous force up to a threshold can provide an optimum force.[28] High initial forces did not achieve greater space closure but resulted in the greater percentage of force decay.[22] NiTi coil springs are believed to provide this constant force,[24] however, one study contradicted this.[22] In sliding mechanics, the force of friction is encountered, which tends to reduce the force available eventually for effective tooth movement.[15] The data so far reviewed proved that elastomeric power chains, elastic threads, magnets, NiTi coil springs,[20] corticotomies,[34] distraction osteogenesis,[27] and laser therapy,[30] all are able to provide optimum rate of tooth movements. All the methods were nearly similar to each other for retraction of canines. No one method can be considered superior to another in terms of faster tooth movement or limited side effects.

### Quality of Analysis

Several methods and scales to incorporate quality into systematic reviews have been proposed and have since been extensively applied to various RCTs in medicine. However, many items were clearly not applicable, for example, placebo appearance/taste, patient blinded, or observer blind to treatment. Instead, the quality of the articles was judged as low, medium, or high according to a scoring system based on the characteristics given in Table 4. Many of the studies had serious defects, and according to the criteria used, the majority of the articles were judged to be of low quality. The most serious shortcomings were retrospective study design in combination with small sample size and inadequate selection description. Problems of lack of method error analysis, the absence of blinding in measurements were other examples of shortcomings. Furthermore, the choice of statistical methods was not explained. In all studies, the methods to analyze canine retraction were valid and well-known.

However, different measurement methods were used to analyze the retraction, which caused difficulties in comparing the results of the studies. From a methodological point of view, it was notable that only 2 of the 22 studies declared the use of blinding in measurements. It is known that nonrandomized trials or RCT without blinding design are more likely to show the advantage an innovation has over a standard treatment method.[12] This implies that the measurements can be affected by the researcher. An RCT is our most powerful tool to evaluate therapy, and the quality of the trial significantly affects the validity of the conclusions. However, randomization is not always possible, and good quality observational studies may be another option.[38] Two RCT studies[22,23] were identified in this systematic review, and both of them were judged to have high quality. In the future, there is a need for additional, well-controlled RCTs concerning the effectiveness of different canine retraction techniques including implant systems and for assessing costs and side effects of the interventions.

## CONCLUSIONS

Two main canine retraction methods were identified: (1) Sliding mechanics (2) Loop mechanics.

- The scientific evidence was too weak to evaluate the efficiency of different canine retraction methods during space closure because a vast heterogeneity of the studies existed
- Sliding mechanics leads to anchorage loss in the molar region in various amounts depending on the method of retraction
- Loop mechanics has its drawbacks but can provide adequate retraction
- Most of the studies have serious problems with small sample size, confounding variables, lack of method error analysis, and no blinding in measurements. No evidence-based conclusions were, therefore, possible to draw from these studies
- Any method of force application would be considered effective as long as it is able to overcome the force of friction and at the same time achieve the maximum rate of tooth movement with as little side effects as possible
- To obtain reliable scientific evidence, additional RCT's with sufficient sample size are needed to determine which canine retraction technique is the most effective. Further studies should also consider patient acceptance and compliance as well as cost analysis.

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