Clinical significance of immediate mandibular lateral translation: A systematic review

Thomas D. Taylor, DDS, MSD, Avinash S. Bidra, BDS, MS, Elena Nazarova, DMD, PhD, and Jonathan P. Wiens, DDS, MSD

Very little in the occlusion literature has caused more discussion, argument, and confusion than the phenomenon of immediate mandibular lateral translation (IMLT). Multiple names have been used to describe this phenomenon: side shift, immediate side shift, Bennett shift, and Bennett side shift. It has been written about extensively, although clinical research into the phenomenon has been minimal.

According to the glossary of prosthodontics terms, IMLT has been defined as "the translatory portion of lateral movement in which the nonworking side condyle moves essentially straight and medially as it leaves the centric relation position." Previous authors have argued that it does not exist or that it is of no clinical significance and may be ignored, while others have argued that IMLT must be recorded and accounted for in the fabrication of all dental restorations. Evidence is currently lacking as to the appropriate emphasis that should be placed on IMLT and the manner of its recording.

The history of IMLT dates back to a manuscript published by Dr. Norman G. Bennett in 1908. In this manuscript, Dr. Bennett described a study in which he participated as the sole participant in an experimental demonstration of mandibular motion. The experiment was performed by using 2 incandescent lightbulbs attached to a mandibular arch bow fastened to the remaining mandibular teeth (Dr. Bennett was missing his mandibular molars). His head was stabilized in a

**ABSTRACT**

**Statement of problem.** Immediate mandibular lateral translation (IMLT) has been widely described in theory, but its clinical significance in prosthodontics and restorative dentistry is not clear.

**Purpose.** The purpose of this study was to systematically review the existing literature to identify the clinical significance of IMLT (immediate side shift).

**Material and methods.** An electronic search for articles in the English language literature was performed independently by multiple investigators using a systematic search process with the PubMed search engine. After applying predetermined inclusion and exclusion criteria, the final list of studies was analyzed to identify the clinical significance of IMLT.

**Results.** The initial electronic search yielded 858 titles. The systematic application of the inclusion and exclusion criteria eventually produced 23 studies addressing IMLT in 914 human participants. Eleven studies reported use of voluntary movements, 5 articles reported use of only induced movements, 2 studies reported use of both voluntary and induced movements, and 5 articles did not report the recording method. The amount of IMLT reported ranged from 0 to 3 mm with minimal clarity among authors on the exact description of IMLT. No studies reported on any clinical implication (harm or benefit to patients or clinicians) of incorporating IMLT in diagnosis and treatment planning.

**Conclusions.** This systematic review did not identify any scientific evidence on the clinical implications of IMLT. Furthermore, there is a lack of clear terminology related to IMLT and the timing of the side shift, occurrence of IMLT on the working versus nonworking condyle, and induced versus noninduced methods of recording and measuring. Current scientific evidence does not support the need to include IMLT as a factor when prosthodontic or restorative treatment is planned and executed. (J Prosthet Dent 2016;115:412-418)
Clinical Implications
When planning and executing prosthodontic or restorative treatment, clinicians may ignore the phenomenon of immediate mandibular lateral translation.

Mandibular translation has been defined as “the translatory (medial-lateral) movement of the mandible when viewed in the frontal plane. While this has not been demonstrated to occur as an immediate horizontal movement when viewed in the frontal plane, it could theoretically occur in an essentially pure translatory form in the early part of the motion or in combination with rotation in the latter part of the motion or both.”

Mandibular translation is comprised of immediate, early, and progressive mandibular lateral translation. Thus, mandibular lateral translation has been shown to change at varying points along the protrusive path, although, by definition, lateral translation from any point other than the centric relation position cannot be considered immediate in nature. The reported incidence of IMLT ranges from being present in no participants to being present in all participants.

Various studies have reported mean IMLT values in the range of 0 to 3 mm, depending on the method of recording, the position of the recording device, and whether the lateral movements were recorded as assisted or unassisted movements. Tupac was the first author to report a significant variation in mechanical pantographic recordings, depending on whether the movements were assisted or unassisted and whether the operator was experienced or inexperienced. His recommendation was to use assisted mandibular movements for recording and programming fully adjustable articulators to ensure the complete reproduction of mandibular border movements. The argument against this recommendation has been that assisted or forced border movements are not reproducible without external guidance and therefore are artificial and of no clinical relevance. Others demonstrated that the clutch angle and the location of the recording table relative to the terminal hinge axis altered IMLT recordings. The use of sedation also affected the recording of IMLT.

Some clinicians have taken the viewpoint that recording and transferring IMLT to the articulator is necessary for the correct fabrication of the occlusal anatomy of posterior teeth. Lundeen and colleagues argued that the movement that occurred at the working condyle was in the same order of magnitude at the occlusal surface of the first molar. Other authors have argued that lateral movement at the level of the condyle is reduced by more than 50% at the level of the first molar because of the overlapping contact of the anterior teeth, particularly the canines, which limit the ability of the mandible to shift laterally while the teeth are in contact with each other.

Despite the extensive historical discussion and publication regarding IMLT, questions remain about the harm that may be done by not accounting for IMLT and the clinical significance of IMLT. The purpose of this systematic review is to attempt to elucidate the clinical significance of IMLT and to clarify the discussion of IMLT.

MATERIAL AND METHODS
An independent electronic search of the English language literature was performed by multiple investigators using the PubMed search engine. The specific terms used for the electronic search were as follows: immediate mandibular lateral translation or mandibular lateral translation or mandibular translation or immediate lateral translation or immediate side shift or immediate mandibular side shift or Bennett side shift or Bennett movement.

The PICO (Patient-Intervention-Control-Outcome) question for this systematic review was as follows: In dentate patients with natural teeth or restored teeth, does immediate mandibular lateral translation as compared with lack of immediate mandibular lateral translation affect any clinical outcomes in prosthodontics and restorative dentistry? The time period searched was from January 1951 to March 1, 2014. The only search limits applied to the electronic search were the English language and humans. The predetermined inclusion criteria were as follows: any English language article on humans in a peer-reviewed journal containing any of the search terms; any article published between January 1951 and March 1, 2014, describing a clinical study involving any of the search terms and at least 1 human participant. The predetermined exclusion criteria were as follows: articles that did not pertain to items...
described in the inclusion criteria; review articles, monographs, or technique articles without associated clinical study and data; in vitro studies, cadaver studies, or animal studies; orthodontic manuscripts in which side shift was meant as a unilateral reverse articulation; participants or data repeated in other included articles; and article descriptions that did not provide clinical data or did not allow extraction of clinical data on immediate mandibular lateral translation.

The electronic search process was systematically conducted in 3 stages. In stage 1, three investigators independently screened all relevant titles of the electronic search, and any disagreement was resolved by discussion. In situations in which the application of the exclusion criteria was not clear, the controversial article was included for consideration in the abstract stage. In stage 2, the investigators independently analyzed the abstracts of all selected titles, and disagreements were resolved by discussion. In situations of uncertainty, the abstract was included for the subsequent full-text stage. After the application of the exclusion criteria, the definitive list of articles was screened at stage 3 by the investigators to extract qualitative and quantitative data. An supplemental search was conducted based on the references from the definitive list of full-text articles from stage 3 and additional articles published beyond the terminal search date (March 1, 2014, to April 30, 2015). Data from all included studies were then tabulated, analyzed, and compared to satisfy the study objectives.

RESULTS

The initial electronic search using the specific search terms from the PubMed search engine yielded a total of 858 titles, out of which 100 abstracts were applicable to the study. Further scrutiny resulted in the elimination of 53 full-text articles. From the remaining 47 full-text articles, another 28 articles were excluded, resulting in a total of 19 studies from which the results were extracted. A supplemental search for articles resulted in 4 additional articles for a total of 23 studies describing IMLT in humans. A subsequent supplemental search for articles published after the terminal search date (March 1, 2014, to April 30, 2015) was done, and no additional articles were identified. Of the 23 studies included for analysis, all studies involved mandibular movement recording of some sort for at least 1 participant (Table 1). The number of participants examined ranged from 1 to 163 for a total of 914 individuals. All 23 studies were observational/cross-sectional without experimental clinical control. The method of recording primarily included pantographic/axiographic recordings and 2 studies used an ultrasound scanning method to demonstrate IMLT. The use of guided or induced mandibular border movements versus voluntary movement was reported in some studies but not in others.

Eleven studies reported using voluntary movements, 5 articles reported using only induced movements, 2 used both voluntary and induced movements, and 5 articles did not report the method of recording. The amount of IMLT reported ranged from 0 to 3 mm with minimal clarity amongst authors on the exact description of IMLT.

None of the studies in this systematic review reported on any specific harm or beneficial effects for patients or clinicians by incorporating IMLT, other than to postulate that the presence of IMLT would alter cuspal pathways in restored occlusal anatomy. No published reports were identified of adverse clinical outcomes such as extensive occlusal adjustments or compromised esthetics and occlusion. No reports were identified of negative patient treatment outcomes such as harm to the restorations or temporomandibular joints by placing restorations without accounting for the IMLT, nor were there any negative consequences of not using pantographic equipment or a fully adjustable articulator.

DISCUSSION

This systematic review did not identify any reports related to actual harm to teeth restorations, periodontium, muscles, or joints as the result of ignoring IMLT in prosthodontic or restorative treatment planning. Most articles identified in this review described the influence of the border IMLT on mandibular movement and did not describe the significance of IMLT at the level of the teeth. Historically, the importance of IMLT has always been hypothesized as a condylar determinant that could impact the occlusal surfaces of posterior teeth. The 23 studies in this systematic review revealed no evidence of clinical factors that must be accommodated in the treatment of patients in whom IMLT has been demonstrated to exist as judged by the clinician. These findings question the relevance of, or need for, IMLT in planning for extensive restorative or prosthodontic treatment. With the emergence of evidence-based prosthetics, clinicians should recognize the distinction between surrogate outcomes and true outcomes. Surrogate outcomes include measures that are not of direct practical importance but are believed to reflect outcomes that are important as part of a disease process. In contrast, true outcomes reflect unequivocal evidence of tangible benefit to the patient. In this regard, recording IMLT is clearly a surrogate outcome that has not been demonstrated in the literature to provide any tangible benefit or harm to the patient or the clinician.
Table 1. Qualitative data on 23 studies identified in systematic review that described data on immediate mandibular lateral translation in humans

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>No. of Participants/ Patients</th>
<th>Age Data of Study Participants</th>
<th>Method of Recording IMLT (Induced or Voluntary)</th>
<th>Amount of IMLT Data Reported by Authors (in millimeters)</th>
<th>Method of Measurement Reported by Authors</th>
<th>Clinical Implication of IMLT (Harm or Benefit to Patient or Clinician) Reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watt, 1968</td>
<td>1</td>
<td>NR</td>
<td>NR</td>
<td>0.2 to 1 mm (from 6 observers on 1 patient)</td>
<td>Pantographic tracings</td>
<td>None</td>
</tr>
<tr>
<td>Preiskel, 1971</td>
<td>18</td>
<td>NR</td>
<td>NR</td>
<td>0.2 to 2 mm in each participant; mean value was 1.07 mm</td>
<td>Ultrasound scanning method</td>
<td>None</td>
</tr>
<tr>
<td>Preiskel, 1972</td>
<td>27</td>
<td>19 to 23 y</td>
<td>Voluntary, and pre-rehearsed</td>
<td>5 participants had less than 0.5 mm; 10 had 0.5 to 1.5 mm; and 7 had more than 1.5 mm</td>
<td>Ultrasound scanning method</td>
<td>None</td>
</tr>
<tr>
<td>Lundeen and Wirth, 1973</td>
<td>50</td>
<td>20 to 55 y</td>
<td>Voluntary, and pre-rehearsed</td>
<td>0 to 3 mm, median was 1 mm; occurred during &quot;first few millimeters&quot;</td>
<td>Movements recorded in plastic blocks engraved by air-turbine drills</td>
<td>None</td>
</tr>
<tr>
<td>Lundeen et al, 1978</td>
<td>163</td>
<td>20 to 65 y</td>
<td>Induced</td>
<td>Mean value was 0.75 mm Almost 80% of participants had 1.5 mm or less</td>
<td>Movements recorded in plastic blocks engraved by air-turbine drills</td>
<td>None</td>
</tr>
<tr>
<td>Tupac, 1978</td>
<td>136</td>
<td>Age was reported for 3 groups (group A–24 to 36 y; group B–23 to 35 y; group C–45 to 62 y)</td>
<td>Induced and Voluntary</td>
<td>Amount of IMLT was age-dependent</td>
<td>Denar pantographic tracings</td>
<td>None</td>
</tr>
<tr>
<td>Bellanti and Martin, 1979</td>
<td>80</td>
<td>Age was reported for 2 groups (first group of 40 participants–15 to 30 y and second group of 40 participants–&quot;over 30 y&quot;)</td>
<td>Voluntary</td>
<td>Mean value was 0.3 mm and 13% of participants had IMLT greater than 0.2 mm</td>
<td>Denar pantographic tracings</td>
<td>None</td>
</tr>
<tr>
<td>Jackson, 1979</td>
<td>3</td>
<td>18 to 20 y</td>
<td>Induced</td>
<td>NR</td>
<td>Denar pantographic tracings</td>
<td>None</td>
</tr>
<tr>
<td>Mongini, 1980</td>
<td>30</td>
<td>20 to 60 y</td>
<td>Voluntary</td>
<td>In 2 patients, IMLT was 2 mm; in 11 patients, range was 0.3 to 1 mm</td>
<td>Lateral tomography in 4 planes at 3 mm intervals plus two pantographic tracings</td>
<td>None</td>
</tr>
<tr>
<td>Simonet and Clayton, 1981</td>
<td>12</td>
<td>21 to 56 y</td>
<td>Induced and Voluntary</td>
<td>On mediotorusive side, voluntary movement ranged from 0.15 to 0.42 mm and for induced movement from 0.15 to 0.56 mm On laterotrusive side, voluntary movement ranged from 0.40 to 1.02 mm and for induced movement from 0.48 to 1.55 mm</td>
<td>Denar pantographic tracings</td>
<td>None</td>
</tr>
<tr>
<td>Levinson, 1984</td>
<td>2</td>
<td>NR</td>
<td>Induced</td>
<td>NR</td>
<td>Pantograph and sirognathograph</td>
<td>None</td>
</tr>
<tr>
<td>Hobo, 1984</td>
<td>50</td>
<td>20 to 50 y</td>
<td>NR</td>
<td>Mean value was 0.79 mm (right condyle); 0.75 mm (left condyle)</td>
<td>Electronic measuring system capable of measuring 6 degrees of freedom</td>
<td>None</td>
</tr>
<tr>
<td>Lundeen and Mendoza, 1984</td>
<td>9</td>
<td>NR</td>
<td>Induced</td>
<td>Right condyle: 1.04 mm for intra-oral measurement and 1.66 mm for extraoral measurement Left condyle: 0.96 mm for intraoral measurement and 1.50 mm for extraoral measurement</td>
<td>Mechanical pantographs</td>
<td>None</td>
</tr>
<tr>
<td>Hobo, 1986</td>
<td>11</td>
<td>21 to 32 y</td>
<td>NR</td>
<td>Mean value was 0.38 mm</td>
<td>Electronic mandibular recording system</td>
<td>None</td>
</tr>
<tr>
<td>Beard et al, 1986</td>
<td>86</td>
<td>15 to 63 y</td>
<td>Voluntary, and pre-rehearsed</td>
<td>Mean value was 0.36 mm</td>
<td>Electronic pantographs</td>
<td>None</td>
</tr>
</tbody>
</table>

(continued on next page)
IMLT can be graphically demonstrated on the articulator, but this “phenomenon” has been difficult to demonstrate clinically. Recognizing the inherent difficulties of recording and demonstrating the presence of IMLT in a patient is an important consideration. Clayton and Kotowicz\(^2^8\) reported that changes in the occlusal vertical dimension, the central bearing guidance surface, and the presence of tooth guidance could all alter the graphical tracings of mandibular movement. Variations in recording IMLT can occur with the orientation of the recording plates, determination of the transverse horizontal axis, patient age, operator induced versus voluntary patient mandibular movement, and neuromuscular release or sedation.\(^6^,8,10,11,19,21\) The presence of canine guidance also decreases the reported measurements of IMLT.\(^2^,3,19\) Additionally, IMLT of the mandible may not be a physically possible phenomenon when the condyles are fully braced against the eminences.\(^1^1\) All of this has led many clinicians to question the existence of IMLT itself.

One of the biggest challenges encountered by the authors of this systematic review was that previous

<table>
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<th>Amount of IMLT Data Reported by Authors (in millimeters)</th>
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<th>Clinical Implication of IMLT (Harm or Benefit to Patient or Clinician) Reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curtis, 1989</td>
<td>20</td>
<td>Mean reported age was 31 y</td>
<td>Voluntary, and pre-rehearsed</td>
<td>Mean value was 0.54 mm but ranged from 0.53 mm to 0.81 mm depending on recording method</td>
<td>Pantographic tracings</td>
<td>None</td>
</tr>
<tr>
<td>Price et al, 1989</td>
<td>2</td>
<td>NR</td>
<td>NR</td>
<td>Amount of IMLT was dependent on type of hinge axis recorded; Right condyle: 0.23 mm for arbitrary hinge axis and 0.14 mm for true hinge axis Left side: 0.19 mm for arbitrary hinge axis and 0.17 mm for true hinge axis</td>
<td>Mechanical Pantronic pantographs</td>
<td>None</td>
</tr>
<tr>
<td>Goldenberg et al, 1990</td>
<td>40</td>
<td>22 to 81 y</td>
<td>Voluntary</td>
<td>Range was 0 to 1.3 mm</td>
<td>Denar pantographic tracings</td>
<td>None</td>
</tr>
<tr>
<td>Gross and Nemcovsky, 1993</td>
<td>7</td>
<td>31 to 57 y</td>
<td>Induced</td>
<td>Amount of IMLT was dependent on TMD status of patient: In participants without TMD, range was 0.5 ±0.7 mm (right) and 0.27 ±0.43 mm (left) In participants with TMD, range was 0.35 ±0.54 (right) and 0.25 ±0.4 (left)</td>
<td>Pantronic</td>
<td>None</td>
</tr>
<tr>
<td>Theusner et al, 1993</td>
<td>49</td>
<td>22 to 56 y</td>
<td>Voluntary</td>
<td>Amount of IMLT was dependent on forward movement of nonworking condyle; record was made At 1 mm, 0.31 ±0.19 mm; at 2 mm, 0.44 ±0.24 mm; at 3 mm, 0.51 ±0.27 mm; at 4 mm, 0.62 ±0.28 mm; at 5 mm, 0.65 ±0.31 mm; at 6 mm, 0.66 ±0.36 mm</td>
<td>SAM axiograph</td>
<td>None</td>
</tr>
<tr>
<td>Zwijnenburg et al, 1996</td>
<td>20</td>
<td>18 to 30 y</td>
<td>Voluntary, and pre-rehearsed</td>
<td>Right condyle range was 0.5 ±0.6 Left condyle range was 0.9 ±0.7</td>
<td>OKAS 3D System</td>
<td>None</td>
</tr>
<tr>
<td>Son et al, 1998</td>
<td>25</td>
<td>23 to 62 y</td>
<td>Voluntary, and pre-rehearsed</td>
<td>Amount of IMLT was dependent on forward movement of nonworking condyle; record was made</td>
<td>Denar Pantograph</td>
<td>None</td>
</tr>
<tr>
<td>Canning et al, 2011</td>
<td>73</td>
<td>22.8 ±6.8 y</td>
<td>Voluntary, and pre-rehearsed</td>
<td>In 39 of 73 participants (55%), values for right side IMLT were 0, and in 50 of 73 participants (70%), values for left side were 0. Of 146 IMLT recordings, only 5 participants measured 0.5 mm or greater</td>
<td>Cadiax</td>
<td>None</td>
</tr>
</tbody>
</table>

NR, not reported; IMLT, immediate mandibular lateral translation.
The authors have not differentiated between immediate and progressive mandibular lateral translation nor have they recorded true border movements versus intraborder movements during functional and operator induced (manipulated) recordings. Reports cited in this systematic review have used inconsistent definitions for IMLT and have attempted to record the presence or absence of IMLT with significantly different methods. In a number of the cited studies, the description of IMLT versus progressive lateral translation is unclear, and the reader has to judge whether, in fact, the authors were measuring a progressive shift but reporting it as an immediate shift. Another important observation in this systematic review is that there is an obvious disagreement between various authors as to whether IMLT should be measured at the working side condyle or at the nonworking condyle. The substantial differences reported in several studies between the amount of IMLT reported when the patient makes passive, unassisted border movements versus assisted or manipulated movements is also a source of disagreement as to the relevance of recording assisted movements that cannot be replicated by unassisted or physiologic movements. Like most systematic reviews, despite an exhaustive search process, the authors may have failed to identify additional articles.29 However, whether incorporating these omitted articles would have changed the conclusions of this systematic review is unknown.

Preiskel2-3 recognized that lateral translatory movements of the human mandible have yet to be completely evaluated, remain elusive, and appear to be unsupported. The current scientific literature reporting on the presence of IMLT reveals that it is inconsistent, of limited magnitude, and has high probability for variability and distortions, thus having minimal clinical implications (for patients and clinicians). These observations reveal the potential to misdiagnose the presence of IMLT and to provide associated well-meaning but misguided or unnecessarily complicated treatment. Moreover, an improved understanding of occlusion and the current emphasis on restoring the dentition with a mutually protected articulation scheme (with canine guidance) has diminished the need for factoring in specific posterior determinants in the articulator that may only occur when the teeth are apart and may therefore be of no clinical importance. To be clinically relevant, IMLT would need to occur when the teeth are in contact, that is, with the elevator muscles contracting and the condyles seated against the glenoid fossae. With the condyles so braced against the fossae, the possibility of immediate lateral movement of the condyles would seem unlikely at best.2,3,11 The findings from this systematic review, therefore, question the clinical relevance and need to include IMLT when prosthodontic treatment is planned and executed.

**CONCLUSION**

This systematic review identified 23 studies in the literature that examined immediate mandibular lateral translation, but none reported on the clinical implications (harm or benefit to clinicians or patients) of this phenomenon. Furthermore, there is a lack of clarity in the terminology related to IMLT and the timing of the side shift, the occurrence of IMLT at the working versus nonworking condyle, and induced versus noninduced methods of recording and measuring. Current scientific evidence does not support the need to include IMLT as a factor when prosthodontic or restorative treatment is planned and executed.

**REFERENCES**

A long-term retrospective analysis of survival rates of implants in the mandible

Balshi TJ, Wolfinger GJ, Stein BE, Balshi SF

**Purpose.** To retrospectively analyze the survival rate of endosseous dental implants placed in the edentulous or partially edentulous mandible over a long-term follow-up period of 10 years or more.

**Materials and Methods.** The charts of patients who underwent mandibular implant placement at a private prosthodontics practice and received follow-up care for 10 years or more were included in this study. Implants were examined according to the following study variables: patient sex, patient age, degree of edentulism (fully vs partially edentulous), implant location, time of loading (delayed vs immediate), implant size and type, bone quality, prosthesis type, and the presence of other implants during placement.

**Results.** The study sample was composed of 2,394 implants placed in 470 patients with 10 to 27 years of follow-up. Of these 2,394 implants, 176 failed, resulting in an overall cumulative survival rate (CSR) of 92.6%. A total of 1,482 implants were placed in edentulous mandibles, and 912 implants were placed in partially edentulous mandibles, with CSRs of 92.6% and 92.7%, respectively. Comparisons of the study variables with respect to CSR were largely nonsignificant. However, there were significant differences in CSRs between anterior vs posterior locations and rough- vs smooth-surfaced implants in addition to some prosthesis types, ages, and bone qualities. The overall CSR of 92.6% in the present study is high and comparable to survival rates observed in previous long-term analyses of mandibular implants. The significant differences observed between implant locations, patient age groups, bone qualities, and prostheses were not suggestive of any remarkable trends.

**Conclusion.** Patient sex, age, degree of edentulism, implant location, time of loading, implant size and type, bone quality, prosthesis type, and the presence of multiple implants did not result in any significant effect on long-term implant survival. The CSR observed after 10 to 27 years of follow-up in a single private prosthodontic center was high (92.6%) and supports the use of endosseous dental implants as a long-term treatment option for the rehabilitation of the edentulous and partially edentulous mandible.

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