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Elastic member clamps

Abstract

The present application generally relates to orthopedic stabilization systems, and in particular, to systems including clamps. The clamps can be used in addition to or to replace hooks that grasp onto bone members, such as the lamina. One example of such a clamp is an in-line clamp that includes a central opening for receiving a rod member, a first opening for receiving a set screw and a second opening for receiving an elastic member therethrough. Another example of such a clamp is an off-set clamp that includes an upper plate, a bottom plate, and an opening for receiving a rod therein. The upper plate can be separated from the bottom plate to make space for an elastic member that can be secured within the plates. Tulip clamps that utilize one or more elastic members are also provided.

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Background/Summary

REFERENCE TO RELATED APPLICATIONS (1) The present application is a continuation of U.S. patent application Ser. No. 16/775,525, filed on Jan. 29, 2020, which is a continuation of U.S. patent application Ser. No. 16/018,368, filed on Jun. 26, 2018 (published as U.S. Pat. Pub. No. 2018-0296251), which is a continuation of U.S. patent application Ser. No. 15/044,251, filed Feb. 16, 2016 (now U.S. Pat. No. 10,034,692), which is a continuation-in-part application of U.S. patent application Ser. No. 14/053,281, filed Oct. 14, 2013 (now U.S. Pat. No. 9,433,441), which is a continuation-in-part application of U.S. patent application Ser. No. 13/785,487, filed Mar. 5, 2013 (published as U.S. Pat. Pub. No. 2014-0257400). Each of these applications is hereby incorporated-by-reference in its entirety for all purposes.

FIELD OF THE INVENTION
(1) The present application is generally directed to orthopedic stabilization systems, and in particular, to systems including clamps and rod members.
BACKGROUND
(2) Many types of spinal irregularities cause pain, limit range of motion, or injure the nervous system within the spinal column. These irregularities can result from, without limitations, trauma, tumor, disc degeneration, and disease. Often, these irregularities are treated by immobilizing a portion of the spine. This treatment typically involves affixing a plurality of screws, hooks and/or clamps to one or more vertebrae and connecting the screws, hooks and/or clamps to an elongate rod that stabilizes members of the spine.
(3) Accordingly, there is a need for improved systems involving screws, hooks and/or clamps for spinal stabilization.
SUMMARY OF THE INVENTION
(4) Various systems, devices and methods related to spinal clamps are provided. In some embodiments, a spinal system comprises a clamp for receiving an elongate rod therein, wherein the clamp comprises an inner opening for receiving the elongate rod, a first opening in communication with the inner opening, and a second opening in communication with the inner opening; a set screw received in the first opening of the clamp; a bushing positioned at a distal end of the set screw; and an elastic member received in the second opening of the clamp, wherein the elastic member is configured to be in contact with the elongate rod received in the clamp.
(5) In other embodiments, a spinal system comprises a clamp for receiving an elongate rod therein, wherein the clamp comprises an inner opening for receiving the elongate rod, a first opening in communication with the inner opening, and a second opening in communication with the inner opening, wherein the inner opening includes a groove for receiving an elastic member therein; a set screw received in the first opening of the clamp; and an elastic member received in the second opening of the clamp, wherein the elastic member is configured to be in contact with the elongate rod received in the clamp.
(6) In other embodiments, a spinal system comprises a clamp for receiving an elongate rod therein, wherein the clamp comprises an inner opening for receiving the elongate rod, a first opening in communication with the inner opening, and a second opening in communication with the inner opening; a set screw received in the first opening of the clamp; a bushing in contact with a distal end of the set screw, wherein the set screw includes a protrusion that extends past a portion of the

bushing; and an elastic member received in the second opening of the clamp, wherein the elastic member is configured to be in contact with the elongate rod received in the clamp.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. **1**A is a top perspective view of an in-line clamp according to some embodiments.

(2) FIG. **1**B is a side cross-sectional view of the in-line clamp in FIG. **1**A.

(3) FIG. **2**A is a side cross-sectional view of an alternative in-line clamp according to some embodiments.

(4) FIG. **2**B is a top perspective view of the in-line clamp in FIG. **2**A.

(5) FIG. **2**C is a side cross-sectional view of the in-line clamp in FIG. **2**A.

(6) FIG. **3**A is a side cross-sectional view of an alternative in-line clamp according to some embodiments.

(7) FIG. **3**B is a top perspective view of the clamp in FIG. **3**A.

(8) FIG. **4**A is a top perspective view of an off-set clamp according to some embodiments.

(9) FIG. **4**B is a cross-sectional view of the off-set clamp in FIG. **4**A.

(10) FIG. **4**C is a top perspective view of the off-set clamp in FIG. **4**A with an elastic member.

(11) FIG. **4**D is a cross-sectional view of the off-set clamp in FIG. **4**A with an elastic member.

(12) FIG. **5**A is a top perspective view of a tulip clamp according to some embodiments.

(13) FIG. **5**B is a side cross-sectional view of the tulip clamp in FIG. **5**A.

(14) FIG. **6** is a top perspective view of an integrated holder and tensioner instrument according to some embodiments.

(15) FIG. **7** is a front cross-sectional view of the integrated holder and tensioner instrument of FIG. **6**.

(16) FIG. **8** is a close-up view of a distal portion of the integrated holder and tensioner instrument of FIG. **6**.

(17) FIG. **9** is an alternate close-up view of a distal portion of the integrated holder and tensioner instrument of FIG. **6**.

(18) FIG. **10** is a close-up view of a proximal portion of the integrated holder and tensioner instrument of FIG. **6**.

(19) FIG. **11** is a close-up view of a distal portion of an alternate integrated holder and tensioner instrument according to some embodiments.

(20) FIG. **12** is a perspective view of an alternative integrated holder and tensioner instrument.

(21) FIG. **13** is a close-up view of a lower member of the integrated holder and tensioner instrument of FIG. **12**.

(22) FIG. **14** is a side view of a lower member of the integrated holder and tensioner instrument of FIG. **12**.

(23) FIG. **15** is a side view of a lower member of the integrated holder and tensioner instrument of FIG. **12**.

(24) FIG. **16** is a side perspective view of a lower member of the integrated holder and tensioner instrument of FIG. **12**.

(25) FIG. **17** is a perspective view of cam locks of the integrated holder and tensioner instrument of FIG. **12**.

(26) FIG. **18** is a perspective view of an alternative integrated holder and tensioner instrument.

(27) FIG. **19** is a close-up view of a lower member of the integrated holder and tensioner instrument of FIG. **18**.

(28) FIG. **20** is a side view of a lower member of the integrated holder and tensioner instrument of FIG. **18**.

(29) FIG. **21** is a side view of a lower member of the integrated holder and tensioner instrument of FIG. **18**.
(30) FIG. **22** is a perspective view of cam locks of the integrated holder and tensioner instrument of FIG. **18**.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

(31) The present disclosure relates to spinal stabilization devices, and in particular, clamps that utilize elastic members to grasp onto bone. The various clamps can be placed in many positions relative to a bone member, such as in-line or off-set.
(32) Many spinal components exist to assist in stabilizing spinal members. Among the components that are used are spinal hooks, which can grasp onto bone. While spinal hooks are effective and can be less disruptive and prone to causing injury compared to other components, such as screws, there is a possibility of the hooks disengaging post surgery, therefore leading to potentially additional surgical intervention to rectify.
(33) The present application is directed to spinal stabilization devices that overcome challenges associated with current spinal devices. In particular, it has been found that spinal clamps can be effectively provided that use elastic members, such as elastic bands, to grasp onto bone members. The use of the elastic members advantageously secures the clamps to bone, and reduces the risk of the devices being inadvertently removed from the bone post-surgery.
(34) FIGS. **1**A-**1**C illustrate different views of an in-line clamp utilizing an elastic member, according to some embodiments. The in-line clamp **10** comprises a body **12** for receiving a rod member **80** therein. The in-line clamp **10** is configured to receive an elastic member **60** therethrough to secure the clamp **10** to a bone member (e.g., a vertebral body).
(35) The in-line clamp **10** includes a body **12** that forms a curved opening or mouth **17** for receiving a rod member **80** therein. As shown in FIG. **1**A, in some embodiments, the curved opening **17** of the body **12** is formed facing downwardly over the rod member **80**, such that the rod member **80** is bottom-loaded relative to the clamp **10**. Advantageously, the curved opening **17** is also configured to receive a portion of the elastic member **60**, which wraps around a vertebral body or bone member. As shown in FIG. **1**A, the elastic member **60** can be positioned such that a first portion of the elastic member **60** is in contact with a first side of the rod member **80** and a second portion of the elastic member **60** is in contact with a second side of the rod member **80** opposite from the first side after looping the elastic member around a bone member. In other embodiments, such as shown in FIG. **2**A, the elastic member **60** can be configured such that portions of the elastic member **60** remain pressed between one-side of the rod member **80** and an inner wall of the clamp **10**, even after looping the elastic member **60** around a bone member. One skilled in the art will appreciate that the positioning of the elastic member **60** relative to the rod member **80** and the clamp **10** can vary, and that the illustrations shown herein are not meant to limit the positions available for placing the elastic member, but rather show options for placing the elastic member in the system.
(36) The curved opening **17** for receiving the rod member **80** is formed by inner walls of the clamp **10**. In some embodiments, the curved opening **17** has a radius that can accommodate both the rod **80** and the elongate member **80** placed therein. As shown in FIG. **1**B, the inner walls of the clamp **10** can include a track or groove **32** formed therein that runs along the inner walls of the clamp **10**. The groove **32** advantageously accommodates the elastic member **60** therein. In some embodiments, the groove **32** has a width that is approximately the same as the width of an elastic member **60** positioned therein. With the addition of the groove **32**, the clamp **10**, rod member **80** and elastic member **60** can be held together, even before tightening the set screw **25** (as discussed below). In some embodiments, the groove **32** runs substantially or completely along the inner walls of the clamp **10**.
(37) The curved opening **17** is in communication with a first opening **14** and a second opening **16**, each of which extends through the body **12** of the clamp **10**. The first opening **14**, which runs

diagonally relative to a vertical mid-plane of the device, is configured to receive a threaded set screw **25** therein. When the rod member **80** and elastic member **60** have been placed in a desired position within the mouth of the clamp **10**, the set screw **25** can be downwardly threaded to apply a compression force on the rod member **80** and elastic member **60** to securely capture the members within the clamp **10**.

(38) In some embodiments, a separate bushing **28** can be attached to a distal end of the set screw **25**, as shown in FIGS. **1**A and **1**B. The bushing **28** advantageously provides an intermediary contact surface between the set screw **25** and the elastic member **60**, thereby preventing the elastic member **60** from fraying or tearing from the contacting the surface of the set screw **25**. As shown in FIG. **1**B, the bushing **28** has a curved contact surface **29** that conforms to the shape of the rod member **80** and elastic member **60** positioned in the mouth of the clamp. The curved contact surface **29** advantageously serves as a pressure distribution surface that comfortably distributes pressure around the rod and elastic member **60** as the threaded set screw **25** is downwardly threaded. In other embodiments, the contact surface **29** of the bushing **28** is partially straight. While the set screw **25** and bushing **28** are illustrated as separate components, in other embodiments, the two components are integrated components. The set screw **25** and bushing **28** can be molded together, or can be formed of a monolithic member. In some embodiments, the set screw **25** and the bushing **28** are formed of different materials, while in other embodiments, the set screw **25** and the bushing **28** are formed of the same materials. In some embodiments, the set screw **25** and/or bushing **28** can be formed of different biocompatible metals, such as stainless steel, titanium or cobalt-chrome.

(39) The second opening **16**, which runs generally through a vertical mid-plane of the device, is configured to receive one or more elastic members **60** therethrough. As shown in FIG. **1**A, this central opening **16** is wide enough to receive two ends or portions of an elastic member **60** that has been looped around a vertebral body. One skilled in the art will appreciate that the positioning of the first and second openings **14** and **16** should not be limited. For example, in alternative embodiments, the positions of the first opening **14** and the second opening **16** can be switched. Alternatively, in other embodiments, the second opening **16** for receiving the ends of the elastic members **60** can be moved away from the vertical mid-plane of the device.

(40) In some embodiments, the elastic member **60** can be a cable. Preferably, the elastic member **60** is a wide elastic band **60**. The use of a wide elastic band **60** can advantageously reduce the risk of damage to tissue lacerations or injury. In some embodiments, the elastic band **60** is between 2 and 8 mm, or greater than 4 mm. In some embodiments, the band is composed of a polymer, such as PET. To ensure that the clamp **10** remains secured to a bone member via the elastic band **60**, a tensioner can be included as part of the system to make sure that the bands are in proper tension and tightness.

(41) The in-line clamp **10** can be used as follows. In some embodiments, the elastic member **60** (e.g., band) can first be introduced to the clamp **10** without the rod **80** inserted therein. The elastic member **60** can be positioned along and within the single groove **32** that extends along an inner surface of the clamp, which advantageously helps to center the elastic member **60**. Both ends of the elastic member **60** can extend through the second hole **16**, thereby forming a loop at the bottom of the elastic member **60**. The loop of the elastic member **60** can be wrapped around a portion of a spine (not shown), such as a lamina. With the elastic member **60** in place, a rod member **80** can be received through the bottom opening **17** of the clamp **10**. Once the rod member **80** is pushed through the bottom opening **17** of the clamp **10** and against the inner walls of the clamp, the rod member **80** is provisionally held in the clamp **10**. At this time, the rod member **80** is advantageously free to translate along the direction of its longitudinal axis.

(42) With the rod member **80** in the clamp, a tensioner can be used to tension the elastic member **60**, thereby pulling the spine to the rod member **80** in order to correct a deformity. When adequate correction is obtained, the set screw **25** can be downwardly threaded to tighten and securely capture

the elastic member **60** and rod member **80**. The bushing **28**, which serves as either a floating piece that is separate from the set screw **25** or an integrally formed piece with the set screw **25**, is positioned at the distal end of the set screw **25** to distribute the tightening load of the set screw **25** uniformly across the elastic member **60** and the rod member **80**. As the set screw **25** is downwardly threaded, the set screw **25** compresses against the elastic member **60** and rod member **80**, thereby securing the system. At this time, the rod member **80** is locked in place and is no longer free to translate.

(43) FIGS. **2**A-**2**C illustrate different views of an alternate in-line clamp **10** according to some embodiments. The in-line clamp **10** in these figures differs from the clamp in FIGS. **1**A and **1**B in that it has a first opening **14**, a second opening **16** and an additional third opening **18** that extends through the body of the clamp. As shown best in FIG. **2**A, the additional third opening **18** is configured to receive two portions or strands of a looped elastic member **60**, which also extend into the second opening **16**. In addition, while the curved opening **17** opens downward such that the rod member **80** remains bottom-loaded, the curved opening **17** is now more diametrically positioned relative to a vertical mid-plane of the device.

(44) In this embodiment, the elastic member **60** passes through both the second opening **16** and the third opening **18**. A loop is formed by the elastic member **60** closer to the third opening **18** and is capable of wrapping around a bone member. In the present embodiments, when a rod member **80** is positioned in the curved opening **17** of the clamp **10**, the elastic member **60** is kept on one side of the rod member **80**. In other words, the elastic member **60** is positioned between the rod member **80** and the inner walls of the clamp **10**, as shown in FIG. **2**A. The addition of the third opening **18** thus provides additional ways to accommodate the elastic member **60** relative to the rod member **80** and the clamp **10**.

(45) FIGS. **3**A and **3**B illustrate different views of an alternative in-line clamp **10** according to some embodiments. The in-line clamp **10** in these figures differs from the clamp in FIGS. **1**A and **1**B in that it has a first opening **14**, a second opening **16**, additional third and fourth openings **18**, **19**, and a unique set screw **25** having an extension member **26**. Both the third opening **18** and the fourth opening **19** are in communication with the opening **17** for receiving a rod member, and are positioned near a lower portion of the clamp **10**.

(46) The clamp **10** is configured to receive an elastic member **60** therethrough. In some embodiments, a first end of the elastic member **60** can extend through the third opening **18** while a second end of the elastic member **60** can extend through the fourth opening **19**, such that both the first and second ends of the elastic member **60** meet and pass through the second opening **16**. A loop is formed at the bottom of the elastic member **60** to receive a bone member. In alternate embodiments, a first end of the elastic member **60** and a second end of the elastic member **60** can pass through the third opening **18** and through the second opening **16** (similar to as shown in FIG. **2**A). In yet further alternate embodiments, a first end of the elastic member **60** and a second end of the elastic member **60** can pass through the fourth opening **19** and through the second opening **16**. With the latter two options, the elastic member **60** can be kept to generally one side of a rod member **80** inserted into the clamp **10**. Accordingly, with the addition of the third opening **14** and the fourth opening **19**, this advantageously provides a number of different options for securing the clamp to bone.

(47) The clamp **10** includes a unique set screw **25** having an extension member **26** formed on a distal end thereof. As shown in FIG. **3**A, the extension member **26** is a shaped protrusion that can extend through the bushing **28**. When the elastic member **60** passes along the inner walls near the bushing **28** (e.g., while entering or exiting the fourth opening **19**), the extension member **26** of the set screw **25** is advantageously configured to contact a portion of the elastic member **60** positioned therein. This additional contact provided by the extension member **26** of the set screw **25** helps to advantageously stabilize the elastic member **60** and, along with the bushing **28**, helps to distribute the compressive load that occurs during downward threading of the screw **25**. In some

embodiments, the extension member **26** comprises a blunt tip to reduce the likelihood of fraying of the elastic member **60**.

(48) FIGS. **4**A-**4**D illustrate different views of an off-set clamp according to some embodiments. The off-set clamp **100** is configured to receive an elastic member **60** (e.g., through slot or opening **116**) on one side of the clamp **100**, and a rod member **80** on an opposite side of the clamp **100**. The clamp **100** comprises an upper plate **110** having a first opening **114** and a second opening **116** and a lower plate **120**. The first opening **114** is configured to receive a set screw **125** that extends through the upper plate **110** and the lower plate **120**. The second opening **116** is configured to receive an elastic member **60** as discussed below.

(49) As shown in FIG. **4**B, the upper plate **110** can be physically separated and lifted away from the lower plate **120**, thereby providing a space **130** for receiving one or more portions of an elastic member **60** therethrough. In some embodiments, the upper plate **110** can translate both vertically and rotationally relative to the lower plate **120**, thereby providing a large enough space **130** (shown in FIG. **4**B) for receiving an elastic member **60**. The elastic member **60** can form a loop that extends around a bone member, with a first portion of the elastic member **60** in contact with a first lower surface **121** of the lower plate **120** and a second portion of the elastic member **60** in contact with a second lower surface (not shown) on the opposite side of the lower plate **120**. The elastic member's trajectory is shown in FIGS. **4**C and **4**D. In some embodiments, the lower surfaces **121** of the lower plate **120** can comprise an overhang for receiving the elastic member **60** to prevent the elastic member from sliding off of the assembly. With the portions of the elastic member **60** in contact with the lower portions of the lower plate **120**, first and second ends of the elastic member **60** can be inserted through the space **130** (shown in FIG. **4**B) created when the upper plate **110** is separated from the lower plate **120**. The first and second ends of the elastic member **60** can then be inserted through the slot **116** formed in the upper plate **110**.

(50) With the elastic member **60** in place such that it is looped around a bone member and such that both of its ends pass through the slot **116**, the upper plate **110** can be brought downwardly onto the lower plate **120**, thereby securing the elastic member **60** therein. To ensure that the upper plate **110** is secure to the lower plate **120**, the set screw **125** can be downwardly threaded, thereby compressively bringing the upper plate **110** into a secure relationship with the lower plate **120**. Advantageously, the downward threading of the set screw **125** will also secure a rod member **80** received in the rod opening **117** formed on the opposite ends of the clamp **100**. In other words, in some embodiments, the downward threading of the set screw **125** will both secure the elastic member **60** within the upper and lower plates on one side of the clamp **100**, and simultaneously secure an off-set rod member **80** that is positioned in a rod opening **117** on an opposite side of the clamp **100**.

(51) When the upper plate **110** is removed from the lower plate **120** (e.g., vertically and/or rotationally) such that an elastic member **60** can be received in the space **130**, the clamp **100** can be considered to be in an “open” or “unlocked” configuration. When the upper plate **110** is downwardly secured to the lower plate **120** (e.g., via the set screw **125**) such that the elastic member **60** is secured within the upper plate **110** and the lower plate **120**, the clamp **100** can be considered to be in a “closed” or “locked” configuration.

(52) The off-set clamp **100** can be used as follows. When the clamp is ready to receive the elastic member **60** and rod member **80**, the upper plate **110** can be raised and rotated slightly from the lower plate **120** to provide room (e.g., space **130**) for inserting an elastic member (e.g., band) **60** between the upper plate **110** and the lower plate **120**. The elastic member can wrap around a spinal portion (e.g., a lamina), and can extend along the outer, bottom side walls **121** of the lower plate **120**. The bottom side walls **121** of the lower plate **120** can include an overhang to prevent the elastic member **60** from sliding off the clamp **100**. Both ends of the elastic member **60** can continue to extend through the slot **116** formed in the upper plate **110**. On the opposite side of the clamp **100**, a rod member **80** can be received between the upper plate **110** and the lower plate **120**. Before

tightening the set screw **125** that extends between the upper plate **110** and the lower plate **120**, the rod member **80** is provisionally held in the clamp **100** and is advantageously free to translate along its longitudinal axis. With the elastic member **60** wrapped around a bone member and the clamp **100**, and the rod member **80** received on the opposite end, the set screw **125** can be tightened such that the clamp **100** clamps down on both the elastic member **60** and rod member **80**. This advantageously secures both the elastic member **60** between the upper plate **110** and lower plate **120** on one side of the clamp **100**, and the off-set rod member **80** within the rod opening **117** on the opposite side of the clamp **100**.

(53) FIGS. **5**A and **5**B illustrate different views of a tulip clamp according to some embodiments. The tulip clamp **200** comprises a first arm **202** and an opposing second arm **204** that join at a base, thereby forming a U-shaped channel for receiving a rod member **80**. The first arm **202** comprises a first angled slot or opening **214** for receiving a first end of an elastic member **60** therethrough and the second arm **204** comprises a second angled slot or opening **216** for receiving a second end of the elastic member **60** therethrough. The bottom of the elastic member **60** can form a loop that passes through a third opening **218** formed at the base of the tulip clamp. The loop is capable of looping around a bone member, such as a lamina.

(54) Advantageously, as shown in FIG. **5**B, the third opening **218** of the tulip clamp **200** has slanted inner walls. These inner walls advantageously serve as a guide for first and second portions of the elastic member **60** prior to the elastic member **60** opening into a loop below the clamp **200**. In some embodiments, the third opening **218** has a width that is greater than a maximum width of the first opening **214** and/or the second opening **216**.

(55) The tulip clamp **200** can be used as follows. An elastic member **60** can first be inserted through the tulip clamp **200** by passing first and second ends of the elastic member **60** through the base opening **218**. The first end of the elastic member **60** can pass through the angled slot or opening **214**, while the second of the elastic member **60** can pass through the angled slot or opening **216**. The bottom of the elastic member **60** forms a loop that can be wrapped around a spinal portion, such as a lamina. With the elastic member **60** in place, a rod member **80** can be introduced into the U-shaped channel of the tulip head, such that the elastic member **60** contacts the rod member **80** on two sides. After the rod member **80** is delivered downwardly into the tulip head, a locking cap including a set screw (not shown) can be delivered onto the rod member **80**. In some embodiments, the locking cap can rest in locking cap slots **231** found in the arms. In some embodiments, the set screw is threaded and interacts with threads on the arms of the tulip clamp. In other embodiments, in lieu of a set screw and locking cap, a single non-threaded locking cap can be provided. Prior to locking the set screw, the rod member **80** can be provisionally captured such that it is advantageously free to move along its longitudinal axis. With the elastic member **60** and rod member **80** in place, a tensioner can tension the band to pull the spine up to the rod member **80** to correct a deformity. Once the deformity is corrected by tensioning the band, the set screw in the locking cap can be downwardly tightened to secure the rod member **80** and elastic member **60** within the tulip clamp **200**.

(56) The clamps discussed above can be accompanied by one or more instruments to facilitate insertion and implantation. For example, in order to properly install a clamp, a tensioner may be used to help tension the elastic member while it is wrapped around a bony structure. The tensioner can hold the elastic member in a corrected position until the set screw of the clamp is finally tightened to securely hold the construct. Accordingly, the clamps can be accompanied by at least two instruments—a holder instrument to facilitate insertion and delivery of the clamp, and a tensioner instrument to hold the elastic band in tension prior to securing the construct.

(57) Alternatively, a novel integrated holder and tensioner instrument can be provided to facilitate insertion and implantation of a clamping assembly. FIG. **6** is a top perspective view of an integrated holder and tensioner instrument according to some embodiments. By providing an integrated holder and tensioner, the instrument advantageously reduces the need for multiple instruments, and

provides a secure means for installing the clamp and elastic member assembly securely.
(58) As shown in FIG. **6**, the integrated holder and tensioner instrument **300** comprises a distal portion comprising a clamp holder **310** for holding a clamp. The clamp holder **310** is operatively connected to an outer sleeve **320** which includes one or more slots **322** through which an elastic member can pass therethrough. Adjacent to a proximal portion of the outer sleeve **320** is an elastic member lock base or carriage **340** and an elastic member lock **330**, the latter of which is also designed to receive an elastic member therethrough. The integrated instrument **300** further includes a tensioner driver **350** for tensioning an elastic member and a clamp holder handle **300** for opening and closing the clamp holder **310**. Each of these components is discussed in greater detail below.
(59) In some embodiments, a distal portion of the instrument **300** comprises a clamp holder **310** for receiving a clamp therein. The clamp holder **310** comprises a pair of fingers or tips **312** that can flex open to receive a clamp therein. The tips **312** are capable of flexing via flexible slits or cuts **314**, as shown in FIG. **7**. The clamp holder **310** can have two configurations: an “open” configuration, whereby it is capable of provisionally and gently holding a clamp therein, and a “closed” configuration, whereby it grips the clamp therein securely and tightly. The clamp holder **310** can be in the open configuration when it first grasps a clamp **10** therein. Once the clamp **10** is provisionally captured in the clamp holder **310**, the clamp holder **310** can be placed in a closed configuration to tighten the grip on the clamp **10**. This can be accomplished by rotating the clamp holder handle **360**, which causes the outer sleeve **320** to translate downwardly onto the clamp holder **310**, thereby preventing the tips **312** of the clamp holder **310** from flexing open.
(60) The outer sleeve **320** comprises an elongate body that is operably attached to the clamp holder **310**. A distal portion of the outer sleeve **320** is configured to include a pair of elongated slots **322**. The elongated slots **322** are configured to receive the ends of the elastic member after the elastic member has been passed through the clamp (as shown in FIG. **1**A) and into the distal end of the outer sleeve **320**. Each end of the elastic member can pass through a slot **322** formed in the outer sleeve and can extend along the length of the outer sleeve, whereby they can be received in the elastic member locks **330**.
(61) The elastic member locks **330** comprise a pair of “wing” shaped members designed to receive an elastic member therein. In some embodiments, each of the elastic member locks **330** comprises an opening or slit **332** for receiving and capturing an end of the elastic member. As the elastic member passes through an elastic member lock **330**, the elastic member lock **330** captures and secures the elastic member via a one-way, unidirectional auto-tightening mechanism, thereby preventing the elastic member from backing out from the elastic member lock **330**. In other words, an elastic member that passes through the elastic member lock **330** can be pulled in tension, without worrying about backing out of the elastic member. The one-way, auto-tightening mechanism can comprise different types of mechanisms, including cam, grooved, flat, and/or rounded surfaces whereby once engaged, they prevent sliding of the elastic member within the lock **330**. When desired, an elastic member can be released from an elastic member lock **330** by pressing the elastic member lock **330** downwardly, thereby actuating a release function.
(62) The elastic member locks **330** are positioned adjacent to the elastic member lock base or carriage **340** and the tensioner driver **350**, which work in conjunction to place the ends of the elastic member in tension. By rotating the tensioner driver **350**, this causes the elastic member lock base or carriage **340** to translate along the longitudinal axis of the outer sleeve in a proximal direction away from the clamp **10**. This movement of the elastic member lock base **340** pulls on the elastic member, thereby placing the ends of the elastic member (which are constrained to the elastic member locks **330**) in greater tension.
(63) In addition to these features, the integrated instrument **300** includes a clamp holder handle **360** positioned at a proximal portion of the instrument **300**. As discussed earlier, the clamp holder handle **360** is capable of actuating the outer sleeve **320**, thereby causing the clamp holder **310** to be in an “open” or “closed” position.

(64) Methods for using the integrated holder and tensioning instrument **300** are now described. In some embodiments, a surgeon would select a clamp **10** to be inserted into a patient. The surgeon can then engage the instrument **300** to the clamp **10** via the clamp holder **310**. The clamp holder **310** is in an “open” configuration, and is only provisionally engaged with the clamp **300**. After provisionally engaging the clamp holder **310** to the clamp **10**, an elastic member (e.g., a band) can be passed through the clamp **10** and out through the clamp holder **310** and the slots **322** of the outer sleeve **320**. In addition to retaining the clamp **10**, the clamp holder **310** can be used to provisionally retain a rod member that is forced into the clamp **10**. With the rod and elastic member provisionally retained within the clamp **10** and clamp holder **310**, the surgeon can rotate the clamp holder handle **360** to place the clamp holder **310** in a “locked” configuration, thereby tightening the grip on the clamp **10**.
(65) At this time, the ends of the elastic member can be passed through the elastic member locks **330**, thereby securely capturing the ends. Once the ends of the elastic member are captured in the elastic member locks **330**, the tensioner driver **350** can be rotated to place further tension on the elastic member's ends. Once the elastic member has been placed in a desired amount of tension, the surgeon can use a hex driver to tighten the set screw **25** of the clamp **10** to thereby secure the clamp member, rod member and elastic member. As the clamp **10** and its associated elastic member are now assembled, the surgeon can either (i) unlock the elastic member locks **330** to slide the elastic member ends out or (ii) cut the elastic member on either side without unlocking the elastic member locks. The clamp holder **360** can then be rotated to disengage the instrument **300** from the installed clamp **10**, thereby allowing the instrument **300** to be removed from the assembled clamp construct in the patient. Optionally, as the ends of the elastic member are loose, the surgeon may choose to cauterize the ends to prevent fraying of the loose ends.
(66) In addition to the components discussed above, the integrated holder and tensioner instrument **300** can further include other components. In some embodiments, the tensioner instrument **300** can be accompanied by a counter torque device (not shown) that can be attached to the counter torque attachment surface **370** on the elastic member base **340**. The counter torque device helps to limit rotation to only those component necessary when rotating the tensioner driver. In addition, the tensioner instrument **300** can also be accompanied by a secondary handle that attaches to the clamp handle **360** to limit or indicate the amount of torque being applied, thereby advantageously preventing over-tensioning of the elastic member.
(67) FIG. **7** is a front cross-sectional view of the integrated holder and tensioner instrument of FIG. **6**. From this view, one can see the cross-section of the clamp holder **310**, including the flexible cuts or slits **314** that enable flexion of the clamp holder tips **312**.
(68) FIG. **8** is a close-up view of a distal portion of the integrated holder and tensioner instrument of FIG. **6**. From this view, one can see the upper opening **16** in the clamp **10** through which the ends of the elastic member can pass before passing through the slots **322** in the outer sleeve **320**.
(69) FIG. **9** is an alternate close-up view of a distal portion of the integrated holder and tensioner instrument of FIG. **6**. From this view, one can see a rod member **80** that is provisionally captured in the clamp **10** via the clamp holder **310**. To tighten the grip on the rod member **80** and clamp **10**, the outer sleeve **320** can be translated downwardly to compress the flexible tips of the clamp holder **310**, thereby causing the clamp holder **310** to be in a “closed” tight position.
(70) FIG. **10** is a close-up view of a proximal portion of the integrated holder and tensioner instrument of FIG. **6**. From this view, one can see the opening or slit **332** formed in each of the elastic member locks **330**, through which an elastic member can pass through. The slit **332** serves as a contact or locking surface of the elastic member, which is configured to pass through each of the elastic member locks **330** prior to tensioning the elastic member.
(71) An alternate design of an integrated holder and tensioner instrument is now described. FIG. **11** is a close-up view of a distal portion of an alternate integrated holder and tensioner instrument according to some embodiments. The instrument in FIG. **11** shares many features with the

instrument in FIG. **6**, including a clamp holder, an outer sleeve, elastic member locks, an elastic member base, a tensioner driver, and a clamp holder handle. However, in contrast to the instrument in FIG. **6**, the instrument in FIG. **11** comprises a clamp holder **310** having a pair of hinged tips **312**. The hinges **317** allow the tips **312** to open and close on a clamp and/or rod member similarly to the instrument in FIG. **6**. In further contrast to the instrument in FIG. **6**, the instrument in FIG. **11** can also include one or more teeth for securing the clamp holder **310** to the outer sleeve **320**.

(72) Additional integrated holder and tensioner instruments are shown in FIGS. **12-22**. The instruments **400**, **500** shown in these embodiments include a number of distinct advantages. In particular, the instruments **400**, **500** allow for elastic members to be advantageously side-loaded into the instruments, which allows for ease of engagement between the elastic members and their respective instruments. In addition, the instruments **400**, **500** advantageously have lower members **402**, **502** that are capable of separation from respective upper members **404**, **504**. This allows for greater visibility during the surgical procedure, as will be discussed in greater detail below.

(73) FIG. **12** is a perspective view of an alternative integrated holder and tensioner instrument in accordance with some embodiments. The instrument **400** comprises a lower member **402** and a separable upper member **404**. The lower member **402** comprises a bottom cam lock **430** having a side opening **431** for receiving an elastic member therethrough. An upper member **404** is attachable to the lower member **402**. The upper member **404** further includes a top cam lock **460** having a side opening **461** for receiving the elastic member therethrough. The top cam lock **460** can be attached to a moveable elastic member lock base or carriage **440**. Translation of the carriage **440** (e.g., via a tensioner driver **450**) in an upward direction causes the tension on the elastic member to increase, while translation of the carriage **440** in a lower direction reduces tension on the elastic member.

(74) Advantageously, the instrument **400** can allow for sequential reduction of the spine by providing a low profile lower member **402** that can retain tension on the elastic member. The instrument **400** is advantageously designed such that the lower member **402** can be attached to a bone member without the upper member **404** attached thereto. The lower member **402** can then receive a portion of the elastic member therethrough with minimal obstruction. The lower member **402** is designed to advantageously retain tension on the elastic member, while maintaining a low profile prior to attachment of the upper member **404**. When the elastic member is ready to be tensioned further, the upper member **404** can simply be fitted onto the lower member **402** (e.g., via a snapfit or connection), and the elastic member can then be received through the top cam lock **460**. The tensioner driver **450** can then be rotated, thereby causing upward translation of the carriage **440** and top cam lock **460**. This increases the tension in the elastic member.

(75) As shown in FIG. **12**, the lower member **402** comprises a shaft **409** having a distal end that is operably attached to a clamp holder **410**. A sleeve **420** extends around the shaft **409**. The clamp holder **410** comprises at least two sets of fingers or tips **412** that are configured to grip a clamp **10** therein. The clamp holder **410** can comprise proximal nubs or hinges **411** that interact with the sleeve **420**, as will be discussed further below. The clamp holder **410** is configured to hold both a clamp **10** and a rod member **80** within the clamp (as shown in FIGS. **14** and **15**).

(76) The clamp holder **410** is capable of provisionally retaining a clamp **10** therein simply by applying a downward force on the clamp **10**. The shaft **409** of the lower member **402** comprises a cut portion that extends along a longitudinal axis of the lower member **402**. In particular, the shaft **409** comprises a circular or rounded flex cut **428** and an elongated cut **429**. These cuts **428**, **429** advantageously allow the fingers **412** of the clamp holder **410** to spread open, thereby retaining the clamp **10** therein upon application of downward force to the clamp **10**.

(77) The clamp holder **410** is also capable of receiving and retaining a rod member **80** within the clamp **10**. To retain the rod member **80**, the fingers **412** are first moved into a spread “open” configuration, as shown in FIG. **14**. To move the fingers into the open configuration, the sleeve **420** can be pulled upward via a pair of wings **422**. In some embodiments, the sleeve **420** is spring-loaded. As the sleeve **420** is pulled upward, the distal end of the sleeve **420** is removed from

engagement with the proximal nubs **411** of the clamp holder **410**, which thereby allows the fingers **412** to spread into the open configuration. With the fingers **412** in the open configuration, a rod member **80** can be delivered into the clamp holder **410**. Once the rod member **80** is delivered therein, the wings **422** can be released. Releasing the wings **422** causes the spring-loaded sleeve **420** to return to its original configuration, whereby its distal end is in engagement with the proximal nubs **411** of the clamp holder **410** (as shown in FIG. **12**). This moves the fingers **412** into a “closed” configuration, as shown in FIG. **15**, which thereby encloses the rod member **80** therein.
(78) The clamp **10** that is retained within the clamp holder **410** can include an elastic member. The elastic member can extend through a side-loaded opening **431** of the bottom cam lock **430**, thereby advantageously placing the elastic member in tension. In some embodiments, the bottom cam lock **430** is spring loaded. As the elastic member is extended through the bottom cam lock **430**, the spring loaded feature allows the elastic member to be retained within the bottom cam lock **430**. To release the elastic member from the bottom cam lock **430**, the bottom cam lock **430** comprises a release latch **432**. Movement of the release latch **432** enables controlled movement of the elastic member within the bottom cam lock **430** as desired.
(79) The lower member **402** is advantageously capable of attachment to bone member without the upper member **404** attached thereto. This allows for enhanced visibility of the surgical site by providing an instrument that is less obstructive.
(80) As shown in FIG. **12**, the upper member **404** comprises a distal shaft **442**, an outer shaft **443** that extends around the distal shaft **442**, an elastic member lock base or carriage **440** attached to the distal shaft **442**, a tensioner driver **450** for translating the carriage **440**, and a threaded shaft **480** extending through the tensioner driver **450**.
(81) The distal shaft **442** of the upper member **404** comprises a cylindrical shaft that is sized and configured to be received in an opening of the lower member **402**. In some embodiments, the distal shaft **442** comprises a smooth outer surface. The distal end of the distal shaft **442** comprises one or more members that allow for a quick connection with the lower member **402** (e.g., via a snap fit).
(82) The outer shaft **443** of the upper member **404** comprises a cylindrical shaft that is sized and configured to extend around the distal shaft **442**. In some embodiments, the outer shaft **443** comprises a shaft release button **444**. When the release button **444** is pressed down, this disengages the distal shaft **442** from the lower member **402**, thereby allowing for removal of the upper member **404** from the lower member **402**.
(83) The carriage **440** of the upper member **404** is attached to a proximal end of the outer shaft **443**. A top cam lock **460** extends from the carriage **440**. The top cam lock **460** comprises a side-loaded opening **461** that allows an elastic member to be side-loaded therein. In some embodiments, an elastic member can be extended through the bottom cam lock **430** and into the top cam lock **460**, whereby it can be further tensioned. The top cam lock **460** further comprises a release latch **462**. Movement of the release latch **462** releases the elastic member if desired, thereby reducing tension on the elastic member. In some embodiments, the top cam lock **460** is spring loaded, such that upon release of the top cam lock **460**, the top cam lock **460** will go back to its original position and retain the elastic member therein. In addition, the carriage **440** of the upper member **404** comprises a counter torque attachment surface **470** which can be gripped by a counter torque device. The counter torque device helps to limit rotation to only those components necessary when rotating the tensioner driver. In some embodiments, the carriage **440** is capable of translation via the tensioner driver **450**, thereby increasing the tension on the elastic member.
(84) The tensioner driver **450** of the upper member **404** comprises a cylindrical member that is attached to a proximal end of the carriage **440**. The tensioner driver **450** can comprise a base portion that is received in a cut out portion **441** of the carriage **440**, thereby retaining the tensioner driver **450** to the carriage **440**. The tensioner driver **450** includes internal threads that are configured to engage external threads of the threaded shaft **480**. Rotation of the tensioner driver **450** in a first direction causes the tensioner driver **450** to rotate upwardly along the threaded shaft

480. As the tensioner driver **450** is attached to the carriage **440**, the carriage **440** also translates upwardly, thereby increasing tension on the elastic member attached to the carriage **440**. Rotation of the tensioner driver **450** in a second direction causes the tensioner driver **450** to rotate downwardly along the threaded shaft **480**. This causes the carriage **440** to translate downwardly, thereby reducing tension on the elastic member attached to the carriage **440**. In some embodiments, the tensioner driver **450** comprises a hex knob.

(85) The threaded shaft **480** of the upper member **404** comprises external threads that engage internal threads of the tensioner driver **450**. In some embodiments, the threaded shaft **480** comprises a proximal cap **484**. Advantageously, the proximal cap **484** serves as a stop that prevents the tensioner driver **450** from going past the cap, thereby reducing the risk of the tensioner driver **450** from falling off the threaded shaft **480**.

(86) The method of using the instrument **400** is as follows. In some embodiments, the lower member **402** is delivered to receive a clamp **10**, which can further receive a rod member **80** therein. An elastic member or band that extends through the clamp **10** can be pulled through a side opening or slot **431** of the bottom cam lock **430**, thereby placing the elastic member in tension. The upper member **404** can then be delivered into attachment with the lower member **402**, whereby it can be attached via a quick connection (e.g., a snap fit). The elastic member can then be pulled through a side opening or slot **461** of the top cam lock **460**, whereby it can be retained in further tension. To increase tension on the elastic member, the tensioner driver **450** can be rotated, thereby causing upward translation of the carriage **440** upon which the top cam lock **460** resides. As the carriage **440** is drawn upwardly, this increases the tension on the elastic member. When the elastic member has achieved its desired tension, a set screw **25** (shown in FIG. **1**A) can be downwardly threaded onto the elastic member, thereby securing the clamp **10** to bone. The instrument **400** can then be removed from the clamp. First, the upper member **404** can be released from the lower member **402** by pressing the release button **444**. Second, the lower member **402** can be released from the clamp **10** by pulling upwardly on the wings **422** of the sleeve **420**. This causes the fingers **412** to open, which thereby allows the clamp **10** to disengage from the instrument **400** if desired. In some embodiments, loose ends of the elastic member can be cut while attached to the instrument **400**. In other embodiments, loose ends of the elastic member are cut after detachment of the instrument **400** from the elastic member. Any remaining loose ends of the elastic member can be glued, singed, or further cut if desired. At this time, the clamp **10** is securely retained on a bone member.

(87) FIG. **13** is a close-up view of a lower member of the integrated holder and tensioner instrument of FIG. **12**. From this view, one can see the shaft **409**, as well as the rounded flex cut **428** and elongated flex cut **429** formed therein. The flex cuts **428**, **429** advantageously help the instrument to retain a clamp **10**, simply by downward force onto the clamp **10**.

(88) FIG. **14** is a side view of a lower member of the integrated holder and tensioner instrument of FIG. **12**. From this view, one can see the fingers **412** in a “open” configuration, whereby a rod member **80** can be received therein. The fingers **412** include at least one hinged portion **413**, whereby in the open configuration, the hinged portion **413** is away from the opposing finger, thereby providing room to receive the rod member **80**. To maintain the fingers **412** in the open configuration, the sleeve **420** is pulled upwardly via its wings **422**.

(89) FIG. **15** is a side view of a lower member of the integrated holder and tensioner instrument of FIG. **12**. From this view, one can see the fingers **412** in a “closed” configuration whereby a rod member **80** is secured therein. In the closed configuration, the hinged portion **413** is nearer to the opposing finger, thereby trapping the rod member **80** within the clamp **10**. To place the fingers **412** in the closed configuration, a surgeon simply needs to release the wings **422**. The spring-loaded action of the sleeve **420** will cause the sleeve to go back to its original location, such that the fingers **412** are placed in the closed configuration.

(90) FIG. **16** is a side perspective view of a lower member of the integrated holder and tensioner instrument of FIG. **12**. From this view, one can see the bottom cam lock **430** close up. The bottom

cam lock **430** includes a side-loaded opening or slot **431** for easily delivering an elastic member therein.

(91) FIG. **17** is a perspective view of cam locks of the integrated holder and tensioner instrument of FIG. **12**. From this view, one can see the bottom cam lock **430**, the top cam lock **460** and the elastic member **60** that extends between the two cam locks. Advantageously, the elastic member **60** is side-loaded into each of the bottom cam lock **430** and the top cam lock **460**, thereby making it easier to retain the elastic member **60** therein.

(92) FIG. **18** is a perspective view of an alternative integrated holder and tensioner instrument. The instrument **500** comprises a number of similar features as the embodiment in FIG. **12**, including a lower member **502** having distal fingers or tips **512** and an upper member **504** separable from the lower member **502**. The lower member **502** comprises a bottom cam lock **530**, while the upper member **504** comprises a top cam lock **560**, each of which is configured to have an opening or slot **531**, **561** for advantageously side loading an elastic member. In some embodiments, the openings **531**, **561** are inline and preserve the visibility of the surgical site during use. As shown in FIG. **18**, the instrument **500** includes an alternate sleeve **511** for placing the fingers **512** in an open or closed configuration, as will be discussed in more detail below.

(93) The instrument **500** comprises a lower member **502** including a shaft **509** having a rounded flex cut **528** and an elongated flex cut **529**. A clamp holder **510** is positioned at a distal end of the shaft **509**. The clamp holder **510** comprises sets of fingers or tips **512** designed to retain a clamp **10** and/or a rod member **80** therein. A spring-loaded sleeve **511** extends over the shaft **509** and is designed to place the fingers **512** in a “closed” or “open” configuration. In its natural state, the sleeve **511** extends distally around fingers **512**, thereby placing the fingers **512** in a closed configuration. To put the fingers **512** in an open configuration whereby they can receive a clamp **10** and/or rod member **80** therein, a sleeve release button **517** can pushed, thereby freeing the sleeve **511** such that it can moved along a longitudinal path. In some embodiments, the sleeve **511** is capable of being moved along a longitudinal path simply by pushing the sleeve release button **517**. With the sleeve release button **517** pushed, the sleeve **511** can be moved upwardly or downwardly, thereby placing the fingers **512** in a “closed” or “open” configuration as desired.

(94) In addition, the lower member **502** further comprises a bottom cam lock **530** having an opening or slot **531** that allows for side-loading of an elastic member. In some embodiments, the bottom cam lock **530** is spring-loaded. To release the elastic member, a release latch mechanism **532** is provided. The release latch mechanism **532** allows for the release of an elastic member once it has been received through the side opening **531**.

(95) The instrument **500** further comprises an upper member **504** including a distal shaft **542**, a lock base or carriage **540** attached to the proximal end of the distal shaft **542**, a tensioner driver **550** attached to the carriage **540** and a threaded shaft **580** extending through the carriage **540**. Advantageously, in some embodiments, the upper member **504** is separable from the lower member **502**. This way, the lower member **502** can be inserted near a surgical site without the upper member **504**, and an elastic member can be received and tensioned via the lower member **502** without obstruction from the upper member **504**.

(96) The distal shaft **542** of the upper member **504** comprises a cylindrical shaft that is sized and configured to be received in an opening of the lower member **502**. In some embodiments, the distal shaft **542** comprises a smooth outer surface. The distal end of the distal shaft **542** comprises one or more members that allow for a quick connection with the lower member **502** (e.g., via a snap fit).

(97) The carriage **540** of the upper member **504** is attached to a proximal end of the distal shaft **542**. A top cam lock **560** extends from the carriage **540**. The top cam lock **560** comprises a side-loaded opening **561** that allows an elastic member to be side-loaded therein. In some embodiments, an elastic member can be extended through the bottom cam lock **530** and into the top cam lock **560**, whereby it can be further tensioned. The top cam lock **560** further comprises a release latch **562**. Movement of the release latch **562** releases the elastic member if desired, thereby reducing tension

on the elastic member. In some embodiments, the top cam lock **560** is spring loaded, such that upon release of the top cam lock **560**, the top cam lock **560** will go back to its original position and retain the elastic member therein. In addition, the carriage **540** of the upper member **504** comprises a counter torque attachment surface **570** which can be gripped by a counter torque device. The counter torque device helps to limit rotation to only those components necessary when rotating the tensioner driver. In some embodiments, the carriage **540** is capable of translation via the tensioner driver **550**, thereby increasing the tension on the elastic member.

(98) The tensioner driver **550** of the upper member **504** comprises a cylindrical member that is attached to a proximal end of the carriage **540**. In some embodiments, the tensioner driver **550** can comprise a base portion that is received in a cut out portion of the carriage **540**, thereby retaining the tensioner driver **550** to the carriage **540**. The tensioner driver **550** includes internal threads that are configured to engage external threads of the threaded shaft **580**. Rotation of the tensioner driver **550** in a first direction causes the tensioner driver **550** to rotate upwardly along the threaded shaft **580**. As the tensioner driver **550** is attached to the carriage **540**, the carriage **540** also translates upwardly, thereby increasing tension on the elastic member attached to the carriage **540**. Rotation of the tensioner driver **550** in a second direction causes the tensioner driver **550** to rotate downwardly along the threaded shaft **580**. This causes the carriage **540** to translate downwardly, thereby reducing tension on the elastic member attached to the carriage **540**. In some embodiments, the tensioner driver **550** comprises a hex knob.

(99) The threaded shaft **580** of the upper member **504** comprises external threads that engage internal threads of the tensioner driver **550**. In some embodiments, the threaded shaft **580** comprises a proximal cap **584**. Advantageously, the proximal cap **584** serves as a stop that prevents the tensioner driver **550** from going past the cap, thereby reducing the risk of the tensioner driver **550** from falling off the threaded shaft **580**.

(100) The method of using the instrument **500** is as follows. In some embodiments, the lower member **502** is delivered to receive a clamp **10**, which can further receive a rod member **80** therein. An elastic member or band that extends through the clamp **10** can be pulled through a side opening or slot **531** of the bottom cam lock **530**, thereby placing the elastic member in tension. The upper member **504** can then be delivered into attachment with the lower member **502**, whereby it can be attached via a quick connection (e.g., a snap fit). The elastic member can then be pulled through a side opening or slot **561** of the top cam lock **560**, whereby it can be retained in further tension. To increase tension on the elastic member, the tensioner driver **550** can be rotated, thereby causing upward translation of the carriage **540** upon which the top cam lock **560** resides. As the carriage **540** is drawn upwardly, this increases the tension on the elastic member. When the elastic member has achieved its desired tension, a set screw **25** (shown in FIG. **1**A) can be downwardly threaded onto the elastic member, thereby securing the clamp **10** to bone. The instrument **500** can then be removed from the clamp. First, the upper member **504** can be released from the lower member **502** by pressing the release button **544**. Second, the lower member **502** can be released from the clamp **10** by pushing the sleeve release button **544** of the sleeve **520** and drawing the sleeve **520** upwardly. This causes the fingers **512** to open, which thereby allows the clamp **10** to disengage from the instrument **500** if desired. In some embodiments, loose ends of the elastic member can be cut while attached to the instrument **500**. In other embodiments, loose ends of the elastic member are cut after detachment of the instrument **500** from the elastic member. Any remaining loose ends of the elastic member can be glued, singed, or further cut if desired. At this time, the clamp **10** is securely retained on a bone member.

(101) FIG. **19** is a close-up view of a lower member of the integrated holder and tensioner instrument of FIG. **12**. From this view, one can see the shaft **509**, as well as the rounded flex cut **528** and elongated flex cut **529** formed therein. The flex cuts **528**, **529** advantageously help the instrument to retain a clamp **10**, simply by downward force onto the clamp **10**.

(102) FIG. **20** is a side view of a lower member of the integrated holder and tensioner instrument of

FIG. **18**. From this view, one can see the fingers **512** in a “open” configuration, whereby a rod member **80** can be received therein. The fingers **512** include at least one hinged portion **513**, whereby in the open configuration, the hinged portion **513** is away from the opposing finger, thereby providing room to receive the rod member **80**. To maintain the fingers **512** in the open configuration, the sleeve **520** is pulled upwardly after pushing on the sleeve release button **517**.
(103) FIG. **21** a side perspective view of a lower member of the integrated holder and tensioner instrument of FIG. **18**. From this view, one can see the bottom cam lock **530** close up. The bottom cam lock **530** includes a side-loaded opening or slot **531** for easily delivering an elastic member therein.
(104) FIG. **22** is a perspective view of cam locks of the integrated holder and tensioner instrument of FIG. **18**. From this view, one can see the bottom cam lock **530**, the top cam lock **560** and the elastic member **60** that extends between the two cam locks. Advantageously, the elastic member **60** is side-loaded into each of the bottom cam lock **530** and the top cam lock **560**, thereby making it easier to retain the elastic member **60** therein.
(105) It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope or spirit of the invention. Moreover, the improved bone screw assemblies and related methods of use need not feature all of the objects, advantages, features and aspects discussed above. Thus, for example, those skilled in the art will recognize that the invention can be embodied or carried out in a manner that achieves or optimizes one advantage or a group of advantages as taught herein without necessarily achieving other objects or advantages as may be taught or suggested herein. In addition, while a number of variations of the invention have been shown and described in detail, other modifications and methods of use, which are within the scope of this invention, will be readily apparent to those of skill in the art based upon this disclosure. It is contemplated that various combinations or subcombinations of these specific features and aspects of embodiments may be made and still fall within the scope of the invention. Accordingly, it should be understood that various features and aspects of the disclosed embodiments can be combined with or substituted for one another in order to form varying modes of the discussed bone screw assemblies. Thus, it is intended that the present invention cover the modifications and variations of this invention provided that they come within the scope of the appended claims or their equivalents.

Claims

1. An elastic band tensioning system for tensioning an elastic band received in a clamp configured to receive a rod, the elastic band configured to wrap around a bone, the system comprising: an outer sleeve defining a longitudinal axis; a lock coupled to the outer sleeve and configured to lock the elastic band that has been wrapped around the bone; an inner sleeve having a distal portion defining a clamp holder, the clamp holder including a plurality of fingers and at least one slit between adjacent fingers to allow the fingers to provisionally hold the clamp; a tensioning driver configured to translate the outer sleeve relative to the inner sleeve to tension the elastic band; and wherein the outer sleeve is configured to transition the clamp holder from the provisional hold to a locking hold of the clamp as the outer sleeve translates distally relative to the inner sleeve.
2. The system of claim 1, wherein the outer sleeve includes a pair of slots sized to let the elastic band pass.
3. The system of claim 1, further comprising a tensioning driver carriage rotatably coupled to the tensioning driver.
4. The system of claim 3, wherein the tensioning driver carriage is slidably and non-rotationally coupled to the outer sleeve.
5. The system of claim 4, wherein the lock includes a lever lock rotatably attached to the tensioning driver carriage.

6. The system of claim 3, wherein the tensioning driver is threadably coupled to the outer sleeve so as to translate the outer sleeve by rotation of the tensioning driver.
7. The system of claim 1, wherein the inner sleeve is slidably and non-rotationally coupled to the outer sleeve.
8. The system of claim 1, further comprising a tensioning driver carriage circumferentially disposed around the outer sleeve and rotatably coupled to the tensioning driver.
9. The system of claim 8, wherein the tensioning driver carriage is slidably and non-rotationally coupled to the outer sleeve.
10. An elastic band tensioning system for tensioning an elastic band received in a clamp configured to receive a rod, the elastic band configured to wrap around a bone, the system comprising: an outer sleeve defining a longitudinal axis; a lock slidably coupled to the outer sleeve and configured to receive and lock the elastic band that has been wrapped around the bone; an inner sleeve having a distal portion defining a clamp holder, the clamp holder including a plurality of fingers and at least one slit between adjacent fingers to allow the fingers to provisionally hold the clamp; a tensioning driver threadably coupled to the outer sleeve and configured to translate the outer sleeve relative to the inner sleeve along the longitudinal axis to tension the locked elastic band by rotation of the tensioning driver; and wherein the outer sleeve is configured to transition the clamp holder from the provisional hold to a locking hold of the clamp as the outer sleeve translates distally relative to the inner sleeve.
11. The system of claim 10, wherein the outer sleeve includes a pair of slots sized to let the elastic band pass.
12. The system of claim 10, further comprising a tensioning driver carriage rotatably coupled to the tensioning driver.
13. The system of claim 12, wherein the tensioning driver carriage is slidably and non-rotationally coupled to the outer sleeve.
14. The system of claim 13, wherein the lock includes a lever lock rotatably attached to the tensioning driver carriage.
15. The system of claim 10, wherein the inner sleeve is slidably and non-rotationally coupled to the outer sleeve.
16. The system of claim 10, further comprising a tensioning driver carriage circumferentially disposed around the outer sleeve and rotatably coupled to the tensioning driver.
17. The system of claim 16, wherein the tensioning driver carriage is slidably and non-rotationally coupled to the outer sleeve.
18. The system of claim 10, wherein the lock is in the shape of a wing with a slit formed therein for receiving the elastic band.